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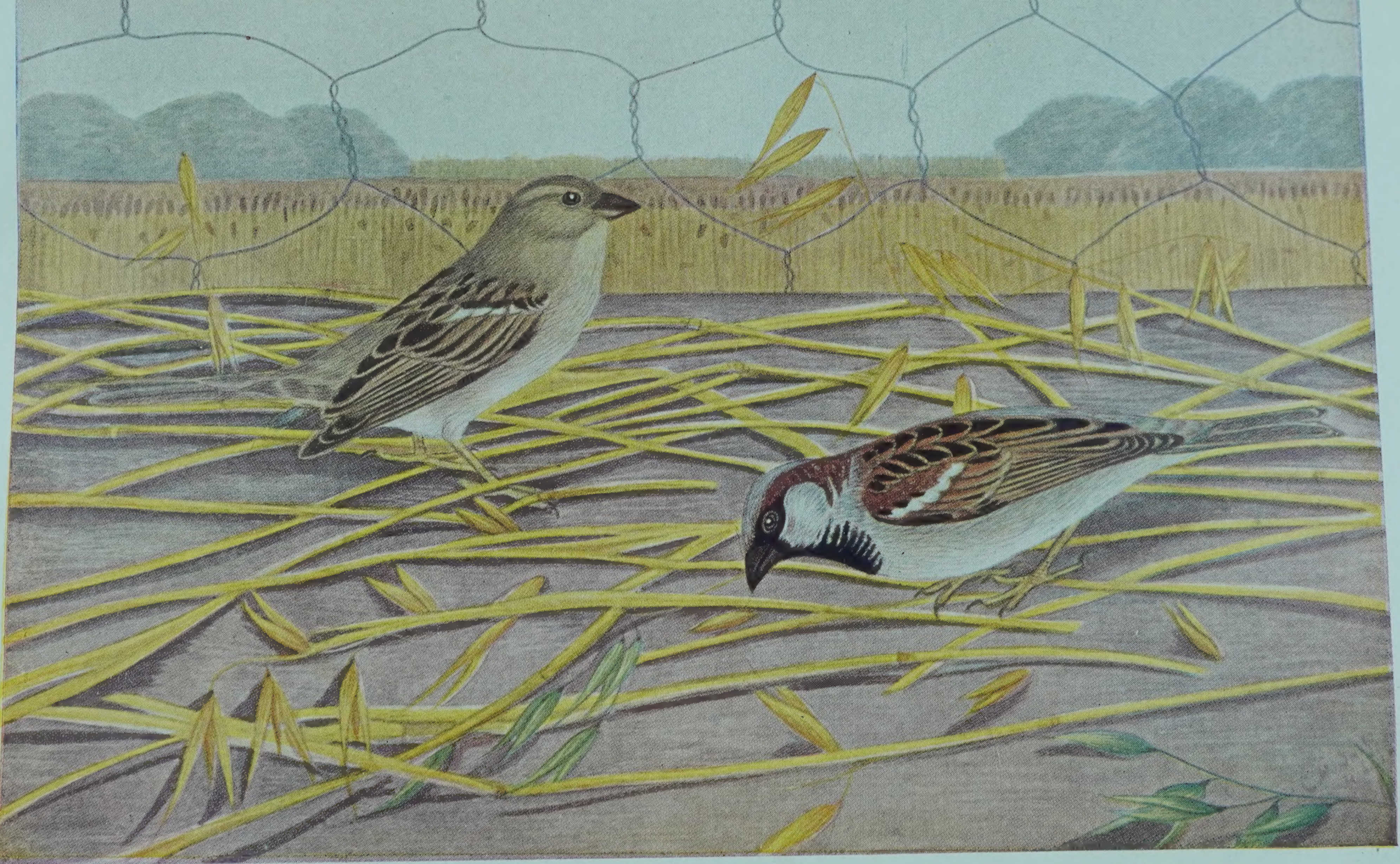

THE INDIAN HOUSE-SPARROW (*PASSER DOMESTICUS INDICUS*).

Original Articles

THE LATE GEORGE ARCHIBALD DOUGLAS STUART, I.C.S.

THE death of Mr. G. A. D. Stuart, I.C.S., Director of Agriculture, Madras, came as a severe blow to the Department which he has so ably directed during the last 5 years and to his many friends in India. Mr. Stuart, who was born on 1st December, 1879, was the son of Mr. G. H. Stuart, a former Director of Public Instruction, and the nephew of Sir Harold Stuart. He was educated at Weymouth School and Emmanuel College, Cambridge. He joined the Indian Civil Service in the year 1902, his first post being that of Assistant Collector of Pollachi Division in the Coimbatore District. Thereafter he was engaged in Settlement work in the Salem District and also in the districts of Chingleput and North Arcot. In 1911 he acted as Director of Agriculture for a short period, and received the permanent appointment in 1916, on the transfer of Mr. D. T. Chadwick to the post of Indian Trade Commissioner in London, which he held to the date of his death. To follow two Directors of the calibre of Mr. M. E. Couchman and Mr. D. T. Chadwick was no light task, but Mr. Stuart soon established himself in the confidence and affection of the members of his Department, and the pleasant relations which existed between them continued to the end. He officiated for Mr. Mackenna in the post of the Agricultural Adviser to the Government of India for six months in 1919. Mr. Stuart's popularity was not confined to Madras and he was a genuine favourite with all the members of the Department throughout India. He was one of the ablest and most popular members of the Board

of Agriculture where his practical commonsense combined with a genuine confidence in his Department earned him the respect of every one.

The affection and esteem in which Mr. Stuart was held by the members of the Madras Agricultural Department has been admirably summarized by one of them as follows :—" His sympathy for the Madras Agricultural Department was whole-hearted. He never promised if he saw no chance of performing. If he promised to help, he helped to the best of his ability and never spared himself. He never took credit that was due to another."

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THE LATE GEORGE ARCHIBALD DOUGLAS STUART, I.C.S.,

SOME COMMON INDIAN BIRDS.

No. 13. THE INDIAN HOUSE-SPARROW (*PASSER DOMESTICUS INDICUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

THE Indian House-Sparrow needs little introduction to our readers, as it is only too familiar throughout India, occurring abundantly in all towns and by no means uncommonly in all country districts. The Indian race differs slightly from the form so familiar in Europe in being usually much whiter about the sides of the head and in having more black below the eye and at the base of the cheeks, so that the Eastern form looks more brightly coloured than the Western, but these characters vary considerably and the Indian race is not now considered as more than a local form of the European species. However, as Hume says, "What is in a name ? Call him *domesticus* or *indicus*, it doesn't alter his depraved nature, does not make him one whit less detestable—only there is a certain *lucus a non lucendo* sarcasm involved in the Linnean name that aggravates.

"If domesticity consists in sitting upon the punkah-ropes all day, chit, chit, chit, chittering ceaselessly when a fellow wants to work, banging down in angry conflict with another wretch on to the table, upsetting the ink, and playing old Harry with

everything, strewing one's drawing-room daily with straw, feathers, rags, and every conceivable kind of rubbish in insane attempts to build a nest where no nest can be—if, I say, these and fifty similar atrocities constitute domesticity, heaven defend us from this greatly lauded virtue, and let us cease to preach to our sons the merits of *domestic* wives! Conceive a wife evincing similar tendencies! Why, there isn't a jury in the country who would not return a verdict of 'sarve her right,' even if the unhappy husband should have wrung her neck before the golden honeymoon had run out."

The above condemnation of the Sparrow is certainly sweeping but there is no doubt that this bird must be regarded as a decided pest of all well-ordered households in a country such as India, where the numerous open doors and windows afford easy entrance and exit and the lofty rooms and verandahs, with their heavy projecting cornices and numerous chinks and crevices, provide the Sparrow with such a convenient variety of suitable nesting-places. Noisy, pugnacious and untidy will perhaps sum up the character of this bird. Cunning, crafty, hardy, and well-nigh omnivorous, it has become a parasite of the human race and is well described by the epithet of "the avian rat," flourishing especially in localities, such as towns, where human activities have upset the normal balance of Nature and destroyed or driven away the natural checks, especially the birds of prey which help to reduce the numbers of this bird in rural areas.

In Europe, America and Australia the House-sparrow is justly regarded as a very serious pest of growing crops and, although relentless persecution is carried on and its numbers kept in check, it is still able to inflict annually loss and damage that can only be reckoned in millions of pounds. In India, things are not quite so bad mainly because the Sparrow is kept in check by natural causes except in large towns. Not only do its disorderly and noisy habits make it an active nuisance in and around houses, but its food consists largely of vegetable matter acquired at the expense of its rightful human owners. Mr. Mason examined the stomach-contents of eight birds at Pusa and Mr. d'Abreu of eight

others at Nagpur and in all cases they were found to contain seeds of various grasses, including cultivated forms such as rice and oats; none of the birds from Nagpur contained any insects and of the eight from Pusa only two contained, between them, two small weevils and another small beetle. The young nestlings, it is true, are fed largely on an insect diet, composed chiefly of caterpillars, but as the young grow older the proportion of insect food given them is diminished until, when they are about three weeks old, their diet is made up almost wholly of grain. The same story is revealed in Australia, whither this bird has been introduced with the unfortunate results so often encountered in the case of introduced animals and plants and in a Bulletin on "The Food of Australian Birds" we read that, of 127 Sparrows examined, sixty-four birds contained wheat and maize seeds and it is remarked that this bird is "a pest anywhere, in spite of the fact that it eats many insects." Besides grass-seeds and occasional insects, the Sparrow does not disdain the smaller fruits and in the mulberry season an extra annoyance is added to its presence in houses owing to its partiality for this fruit.

The nesting season is principally from February to May but two or more broods are undertaken annually and breeding continues throughout the year, the semi-domesticated conditions of this bird's existence not restricting it to any one season of the year. Its nest is a shapeless bundle of straw, grass, rags, wool or anything else obtainable, thickly lined with feathers and stuffed into any available hole or recess in or about houses, walls, old wells, etc., or rarely even in the centre of a thick bush. If a tree or a climber on a wall be chosen for the nesting site the nest is better made and is often a substantial dome-like structure with the entrance at the side, but its position is usually betrayed by long untidy pieces of straw left trailing outside. Five or six eggs, sometimes even more, are laid at each breeding season, the eggs being typically somewhat elongated ovals and but little pointed, either greenish, greyish, or yellowish-white, marked with close frecklings, fine lines or smudgy streaks of dull dingy sepia, olive, yellowish or purplish-brown, these markings being sometimes

sharply defined, and often showing a tendency to form a blotchy, mottled, ill-defined cap at the larger end. The eggs vary much in size but average about 20 mm. long by 15 mm. broad.

Besides the natural enemies of the older birds, the nestlings are attacked whilst in the nest by the grubs of a fly, *Passeromyia heterochæta*, which lays its eggs in the nest and whose larva buries its anterior extremity in the skin of the nestling, usually under the wings or the legs, and sucks its blood. This fly is widely distributed in Africa and has been found in China and in India at Pusa and Coonoor and is probably widely distributed in India. The numbers of the adult birds are largely kept down in the *mofussil* by hawks and probably also by the Indian Vampyre Bat (*Lyroderma lyra*) which hunts by night along the hedges in which these birds congregate in the evening to sleep in flocks, this habit affording an opportunity of netting them in quantity when it is desired to reduce their numbers.

The Indian House-sparrow occurs throughout the entire Indian Empire and in Ceylon but is not found in the Andamans or Nicobars or in the south of Burma. It ascends the Himalayas to moderate elevations. It is only too abundant in most parts of its range but is rare in some localities.

CO-OPERATIVE CONSOLIDATION OF HOLDINGS IN THE PUNJAB.

BY

H. CALVERT, I.C.S.,

Registrar, Co-operative Societies, Punjab.

THERE has been so much written about the evils and drawbacks of excessive fragmentation of holdings that the subject needs no introduction. In the Punjab the average holding is somewhere between six and fifteen acres ; the actual figure depends on whether holdings of less than one acre, and holdings attached to houses, etc., are omitted. This holding is sufficient to maintain a family in decent comfort if the right crops are grown, if the land is put to the best use, if adequate capital is invested and if several other conditions are fulfilled. But for these small holdings, it is essential that the fields should be concentrated in one place, so that the attention, the time, the energy and the intelligence of the cultivator may also be concentrated there. In this province, however, custom orders otherwise. The land is held by the owners of villages either by ancestral shares or by actual possession on the ground ; the tendency now-a-days is for an owner's rights to be measured by the actual area in his possession, plus a share in the village common, or *shamilat*. The universal custom is for sons to inherit equal shares, except where there are sons by different wives, when it sometimes happens that the sons of each wife inherit an equal share and divide amongst themselves. These shares may be held in common, the brothers arranging amongst themselves the fields each shall cultivate or even cultivating in common and sharing the produce. There is a strong

tendency, however, for each brother, especially when he begets a family, to take his own share as his separate property and to leave his brothers alone in the management of their own shares. There is no custom, such as is found in Europe where the Code Napoleon is in force, of the elder brother buying out the younger and so becoming sole proprietor of the ancestral land. The effect of these tendencies is for the land to be held in smaller and smaller parcels; and, as on partition amongst the heirs each claims and expects to get a share in each kind of land, each owner becomes possessed of a number of fields scattered throughout the area of the village. In those portions of the province where the crops were more secure owing to the rainfall being more assured, this fragmentation has proceeded to a greater extent than in districts with precarious rainfall, where a small scattered holding would not have sufficed to maintain a family. Perhaps, this tendency has gone further in Jullundur than in any other district. Jullundur is in the central Punjab; its fertility has led to the growth of a large population pressing heavily on the soil; the facility with which wells can be constructed has led to the land becoming largely dependent on this form of irrigation; the forces making for fragmentation have under these circumstances produced some startling results. In eight villages, the average field does not exceed one-fourth of an acre in area; the 2,549 owners possess 12,800 acres, or about five acres each, but these 12,800 acres are divided into no less than 63,492 fields, so that each owner has on the average 25 fields. In one village, 584 owners own 2,353 acres in 16,311 fields, the average being one-seventh of an acre. In the neighbouring districts of Hoshiarpur and Gurdaspur the process of fragmentation has resulted in similar conditions. In the rest of the province, outside the great canal colonies, somewhat similar features are to be found, though not to so marked an extent.

In Jullundur, owing to the successive partition of holdings, shares in wells have also been divided, so that a man may own a one-sixteenth of one well, and one-eighth of another and so on. The economic loss due to this system may be imagined.

The evils of fragmentation are obvious ; the remedy is not so easy to find. It so happens that the three districts mentioned are those in which co-operation has made most progress, and in which the co-operative spirit has been best developed. It occurred to me that a solution along co-operative lines might be found which would prove acceptable to the cultivators. To this end, I propounded a scheme and discussed it with co-operators and the staff at various meetings ; as a result model by-laws were prepared with an explanatory note, and efforts were made to persuade owners to give the scheme a trial. It was essential that the experiment should rest upon a voluntary basis, for the simple reason that there were no powers of compulsion ; at the same time it appeared necessary to insert a provision for decision by a majority in case one or more owners turned obstructionist. The scheme put forward was as follows :—Each owner had to agree to the desirability of consolidation, and to the general idea of repartition of the village lands with this end in view ; each such owner had then to agree to abide by any plan of repartition approved by two-thirds of all the owners ; and further to give up possession of his own lands and to accept in exchange the lands allotted to him ; all disputes to be referred to arbitration ; possession so given was to be cultivating possession for four years only, on the expiration of this period, the former possession was to be restored unless all the participating owners unanimously agreed to retain the new division as permanent ownership. Persons accepting these conditions could form a Co-operative Consolidation of Holdings Society. The general meeting would discuss the method of partition and decide on the main principles to be observed, such as the kinds of lands, the retention of former possession, and whether minor differences as to trees, etc., should be made good by money payments, and so on. In the case of any difference of opinion, any resolution would only be binding if two-thirds of the members approved of it. If there were not two-thirds of all the members in favour, then it would be necessary to devise some alternative method, or the society would dissolve. When a method of partition had been decided upon, the managing committee was to proceed to draw

up a scheme of repartition in accordance therewith. This scheme was to be placed before the general meeting ; if two-thirds of all the members accepted it, it would be binding on all, otherwise it was to be discarded. If a scheme received the approval prescribed, members were bound to give up and accept possession in accordance with it. A member, who felt aggrieved, could refer the point in dispute to arbitration. Members, thus exchanging land, would be tenants for four years ; during that period, any, who chose to convert this temporary possession into permanent exchange of ownership, were at liberty to do so ; and it was intended and hoped that many, if not most, would do this before the four years elapsed. At the end of four years, members would have to decide whether they would revert to the former possession or make the new scheme permanent or retain the temporary arrangement for a further period. Failing complete unanimity, the fields were to be restored to the former owners, and the society would automatically come to an end at the end of five years. The extra year was allowed for the settlement of disputes by arbitration.

Under this scheme, a member only bound himself for four years ; he agreed to abide by the decision of two-thirds of all the members as to the mode of partition, and by a similar majority as to the actual partition on the ground. He could not be deprived of his old fields beyond four years without his own consent, as an unanimous vote was necessary to convert the exchange into a change of ownership.

This was the scheme. In placing it before the people, the staff relied upon preaching and persuasion, and not upon the element of compulsion. The people soon came to see and appreciate the advantages, but everyone feared that he, at least, would lose by giving up his own very precious fields for someone else's inferior ones. It was obvious that if a revolution of this nature was to be carried through on a permanent basis, everyone must be satisfied and no one must be left discontented. It might be possible to repartition one or two villages by catching the hesitant over the compulsory clauses ; the general idea would fail if there were any disgruntled to decry it throughout the neighbourhood.

With such considerations in view, the power of compulsion by two-thirds majority has so far never been used ; if anyone objects to one plan another is tried and so on until everyone is satisfied ; in one case at least the staff were too anxious for results, and paid too little attention to objections with the consequence that the owners refused to have the decision ratified when it was placed before the Revenue Officer.

Now for the accomplishment. The staff of the Co-operative Department are for the most part sons of actual cultivators, and so in sympathy with rural feeling ; the inspectors are now generally graduates in economics who study practical applied rural economics in the ordinary course of their duties ; they exercise no legal powers at all ; they have to rely upon their powers of propaganda and persuasion ; they are specially educated men speaking to their brethren with knowledge begotten from careful training.

In all 69 Societies for the Consolidation of Holdings have been registered * ; each society has been organized in a different village, but it is not always the whole village that is put to repartition at once. Sometimes a block of land is tried as an experiment, sometimes a subdivision, sometimes the whole area.†

In 45 villages complete or partial repartition has been concluded, in 39 cases the repartition has been confirmed before the Revenue Officer (mutation has been sanctioned), and the change incorporated in the records ; in the remainder, mutation is pending until the officer visits the village. The gross result is that 1,653 owners, who formerly possessed 8,100 acres in 10,906 fields, now have this land consolidated into 2,071 fields.

The reduction in field numbers exaggerates the effect, as in many cases an owner had previously two or more fields contiguous ; but there can be no doubt that the scattered holdings have been changed for solid blocks. The average size of a field before consolidation was three-quarters of an acre ; now it is four acres. In eleven of these villages, before consolidation, the average size

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* Up to the end of September 1921.

† It is of special interest to note that, in several villages where only certain blocks were first readjusted, the owners of other blocks are now asking for help in readjustment.

of a field in each village was not more than half an acre ; now it is less than one acre in only one case, and less than two acres in two more.

In nearly all cases, the exchange of possession has been made permanent from the start. This was not advocated from the fear that a measure too revolutionary might not be found acceptable at first. As a matter of fact, when the owners have got so far as exchange of possession, the plunge into permanency is robbed of its terrors.

Of the economic results, it is too early yet to say much. Prosperity is not built up in a day ; but the reports received show already some changes. In one village it has been possible to get rid of a guard (*rakha*) over the crops, thus saving a sum equal to a considerable proportion of the revenue charged on the land. In Ghazikot rents have increased for the compact blocks, as the tenants find these more easy to manage. In this village the consolidation has created parcels of land which can be irrigated from a well ; previously fields were on the average three-quarters of an acre in area, now the average is over four acres ; the former is too small to justify a well, the latter is large enough to make one profitable ; already six new wells are under construction. Another advantage discovered is that, with larger fields, there is much economy of canal water. To irrigate a number of petty scattered fields involves a waste of water as it has to be carried over a number of channels ; with a consolidated holding this source of waste diminishes. In another village it is proposed to plant fruit trees on portions of the new parcels of land.

In some cases it has been found that the fields were actually too small to make cultivation worth the trouble involved, and were left untouched in consequence ; this difficulty has now disappeared. In one village the owners, after consolidation had given them compact parcels, bought Meston ploughs. These ploughs are not handy for the very small fields, but this difficulty does not remain when the fields are large.

Of difficulties much could be written. Every owner fancies his ancestral plots are the best and dislikes the idea of exchange ; old

men hate to be disturbed, minors require special consideration; the very small owners see no advantage, the bigger men have sometimes got more than they are entitled to and repartition would take this away; mortgagees oppose any alteration, and occupancy tenants fear that their rights will be lost if their possession is disturbed; some owners have migrated in search of work and their consent cannot be obtained. All these must be met and surmounted with patience and tact. Other difficulties are of a different order; the village patwari sees his income from disputes, from copies for court use, and from other little sources threatened with reduction; he also fears that with compact holdings the number of patwaris will be reduced and his conscience suggests that, if the worst men are dismissed, he will not be a survivor. The higher revenue authorities have shown much interest in the work, and as success is achieved, this interest should grow.

The most important feature about the work done is that it has been shown that consolidation can be carried out in actual practice; the stage of discussion and opinion and pious resolution has been left behind. A beginning has been made, a small beginning, perhaps, but still a beginning, which is better than none at all. The year's work marks a definite step forward.

The work demands the utmost sympathy and patience; nothing must be rushed, nothing left unexplained; every man's objection must be removed, even if he be the smallest owner in the society. A village well satisfied with its experiment in consolidation will be of more value for propaganda than many lectures. The cultivators readily grasp the advantages; each is ready to take his neighbour's land, but not so ready to give up his own. The main elements of co-operative action must be carefully preserved. The agreement to join in such a society must be voluntary and based upon the realization of a common need and of the desirability of securing it by common action. Within the society, everyone, be he a big owner or a small one, must have an equal voice; the smallest man may make the loudest complaints; the executive work must be entrusted to an

elected committee but this must be answerable to the general meeting; no one must seek advantage at the expense of his neighbour. The time for any element of compulsion from Government has not yet arrived; there must be a long period during which the measure gains in popularity and acquires the confidence of the majority; public opinion in its favour will grow as more and more instances of the practical advantages can be published abroad. Unless the unexpected happens, years of steady persistent propaganda will be required before the evil of fragmentation has been scotched.

We are not prepared to advocate any legislation at this stage; it is probable that several steps will prove necessary in succession. At present, there seems to be desirable some measure of protection of minors and their guardians, especially of the guardians; it may, for instance, be necessary to provide that an act of consolidation approved by a guardian and by the general meeting shall be presumed to have been done in good faith. Then it may be necessary to enact that mortgage deeds relating to specific parcels of land shall be deemed to apply to the land received in exchange on consolidation. Occupancy tenants, who lose their rights by abandonment or those who have no power to transfer their rights, may need protection, although it is hardly conceivable that any court would penalize a man for consolidation. Then there is the difficulty connected with absentees; in the central districts of the province, it is not uncommon for the poorer cultivators to seek their fortune in America or Australia, etc., without abandoning their rights in their ancestral plots. At present the brother usually guarantees the consent of the absentee, but there are dangers in this. Tenants who claim compensation for disturbance may give trouble, but this should not be beyond adjustment. The time for compulsion has not yet come, but the experience of other countries suggests that without some such power the work will not proceed very far. Hitherto, the propaganda has been carried on amongst co-operators whose experience of the credit society has served to show the advantage of joint

association, and it will be better to let the successful examples speak for the merits of the scheme before any compulsion is contemplated.

The work is proceeding steadily, and it is hoped that about 100 to 150 more villages will be readjusted during the current year.

Statement showing work of consolidation done in 1920-21.

Serial No.	Name of society	No. of members	Area consolidated in Kanals	Previous No. of fields	Present No. of fields	Average area per field in Kanals: Before consolidation	Average area per field in Kanals: After consolidation	Remarks
1	Nowshehra ..	12	1,196	147	21	8	57	Mutations are said to have been sanctioned.
2	Bahadur ..	18	1,112	265	38	4	29	
3	Ghazi Kot ..	10	7,965	1,139	240	6	33	
4	Bhabra ..	24	2,381	479	136	5	18	
5	Jagawal ..	10	994	149	38	7	26	
6	Niamatpur ..	10	660	117	9	6	74	
7	Manoharpur ..	11	1,034	165	7	6	148	
8	Makhanpur ..	10	867	121	17	7	51	
9	Sheikh Kabir ..	16	900	155	46	6	20	
10	Kotla ..	22	470	150	42	3	11	
11	Chak Nooroowala	22	770	140	55	5	14	
12	Bucha Nangal ..	22	1,000	250	58	4	17	
13	Lakhan Kalan ..	11	1,100	155	38	7	29	
14	Gagraoyian ..	10	2,400	350	60	7	40	
15	Nath ..	18	897	96	29	9	31	Mutations not attested yet.
16	Chak Mubarik ..	12	840	81	24	10	35	
17	Bhochra ..	11	3,200	500	164	26	78	Mutations sanctioned.
18	Khurpa ..	21	992	83	16	12	62	
19	Momanpur ..	21	757–18	127	21	6	36	
20	Ghazipur ..	92	2,586–18	825	102	3	25	
	TOTAL ..	383	32,122–16	5,494	1,161	..	..	Carried over

Statement showing work of consolidation done in 1920-21—contd.

Serial No.	Name of society	No. of members	Area consolidated in Kanals	Previous No. of fields	Present No. of fields	Average area per field in Kanals: Before consolidation	Average area per field in Kanals: After consolidation	Remarks
	Brought forward ..	383	32,122–16	5,494	1,161			
21	Bhetthe ..	26	951– 7	174	58	5	17	
22	Alamgir ..	87	2,423– 5	583	59	4	41	
23	Bajra ..	67	827– 8	305	27	3	31	
24	Kahlwan Patti Ram Singh ..	10	727– 6	76	12	10	61	
25	Chotala ..	78	1,363– 3	169	35	8	39	
26	Safdarpur Patti Gujran ..	12	657–14	38	5	17	132	
27	Tur ..	22	349–12	49	15	7	23	
28	Noshera ..	12	1,312– 9	23	19	57	69	Mutations sanctioned.
29	Dhido Kutrala ..	13	702– 2	177	105	4	7	
30	Rajpur ..	11	487– 4	60	14	8	35	
31	Behrampur Patti Bhathian ..	53	2,742–13	200	54	14	51	
32	Behrampur Patti Jailewala ..	75	4,793– 9	255	39	19	123	
33	Saila Khurd ..	73	301–15	116	24	3	13	
34	Badhel ..	17	429– 0	88	8	5	54	
35	Semi ..	45	2,221– 9	703	38	3	60	Mutations pending.
36	Garhshankar Patti Jaora ..	16	1,456– 0	386	16	4	91	
37	Ida ..	88	1,185–15	124	48	10	25	
38	Mohmohial Yusufpur ..	45	1,456– 9	90	20	16	73	Mutations sanctioned.
39	Bir Udhowal Patti Jhangian ..	101	1,292– 2	194	55	7	24	
	TOTAL ..	1,234	57,802–18	9,304	1,812	..	..	Carried over

Statement showing work of consolidation done in 1920-21—*concld.*

Serial No.	Name of society	No. of members	Area consolidated in Kanals	Previous No. of fields	Present No. of fields	Average area per field in Kanals		Remarks
						Before consolidation	After consolidation	
	Brought forward	1,234	57,802–18	9,304	1,812			
40	Dhaliwal Patti Mana ..	181	2,041– 6	679	102	3	20	Mutations sanctioned.
41	Sargondhi Patti Jattan ..	25	903–19	182	19	5	48	
42	Dhanipind Patti Gil ..	57	446– 2	117	25	4	18	
43	Zainpura ..	99	2,017– 0	160	42	12	48	
44	Ball Hukmi ..	17	1,500– 0	341	44	4	34	Mutations pending.
45	Goraya Patti Manga ..	40	289	123	27	2½	11	
	Total ..	1,653	65,000– 5	10,906	2,071	6	31	

COW PROTECTION.*

BY

W. SMITH,

Imperial Dairy Expert.

A GREAT deal has been said and written on this subject in India, and vast sums of money donated by pious Hindus are spent yearly on the maintenance of Pinjrapoles, Gowsalas, and various organizations in order to prevent the slaughter of cows, and to ameliorate the lot of aged and suffering cattle. The cow is held in veneration by the Hindu community, and the whole of the people of India, whether Hindu, Mahomedan, Sikh or Christian, look to her for part of their food-supply in the form of milk, *ghi* (clarified butter), or other milk products. The great mass of Indians are vegetarian, and there is nothing which can take the place of milk and the milk fats in their dietary. Recent investigations have proved that the vegetable oils which are offered as butter fat substitutes are lacking in what is known as vitamines, which are essential to the growth and the general well-being of the body. Most Indians do not eat animal fats and, consequently for the fatty part of their daily ration rich in the necessary vitamine principle, they must rely on butter fat alone.

In view of these facts, it seems that, even from a purely utilitarian point of view, it is good to have a very special regard for the cow and all which pertains to her well-being, and consequently cow protection is a necessary plank in the economic platform of Indian progress.

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* Note sent, on request, to the Principal Director of the Goraksha Mundal, Ltd., Calcutta.

Some prominent men in India advocate prohibition of the export of cattle as a form of cow protection, others call for Government orders prohibiting the slaughter of cattle for food, while a section of the rural community consider that the setting apart by the State of large areas of land for grazing purposes only would solve the problem. No doubt something can be said in favour of all these proposals, but it seems to me that the first and most needful form of cow protection urgently wanted in India is the stoppage of the slaughter of young cows and female buffaloes in the large cities.

In Calcutta and Bombay, and to some extent also in other large cities, practically the total fresh milk supply of the city is produced from cows fed, housed, and milked right within the city limits. These cattle are purchased in the prime of life, and generally with their second calf at heel, they are milked for one lactation period only, say, 9 months, and then immediately slaughtered to make room for another cow just calved, which of course shares the same fate as her predecessor, and so the pernicious system goes on.

Up to sixty years ago, when railways began to serve as transport arteries to and from the great cities of the world, this system, which may be called the "cow-feeding" system, was in vogue in all the great cities of the world, and up to 1864 the whole of the milk consumed in the city of London was produced by "cow-feeders" in or near the city. An outbreak of rinderpest amongst the London cows brought home to the late Sir Geo. Barham, then a London cow-owner, that milk could be purchased at farms in the country, railed into London, and sold there, of better quality, cleaner, and cheaper than the city produced milk. He at once put the idea into practice and made a fortune in so doing, because the production of milk in a large city from cows tied up all the year is not only insanitary and unnatural, but it is uneconomical, and from the point of view of cost it cannot compete with milk produced on the land by a *bonâ fide* farmer who keeps his cows over the dry period and only disposes of them when they have become inefficient through old age, sickness, or accident.

The experience of the city of London has been the experience of practically every large city in the civilized world with the exception of Calcutta and Bombay. The introduction of milk from the country very soon ruined the cow-feeders of Paris, Copenhagen, New York, and Chicago, and to-day no cows are kept in these cities.

It may be asked why have economic conditions not asserted themselves in the Indian capital cities and driven out the cow-feeder as they have done elsewhere. The reasons are many. Firstly, there is a prejudice amongst Indian consumers against pasteurized milk, and of course in a climate like India milk cannot be sent from the country into the city unless it has been pasteurized and cooled. Secondly, the dairy industry in India has not been taken up by the trained business capitalist, but is carried on by poor men, uneducated and generally without organizing ability; and, thirdly, these men who work the milk trade in India have not the requisite technical knowledge to know how to treat milk intended for consumption some distance from the source of production, nor for that matter is there any school or college in the country where they can acquire such knowledge. India is the only civilized country in the world to-day which has no properly equipped dairy school or college. An attempt at teaching dairying has been made at some of the agricultural colleges, but only as part of a general agricultural curriculum, and it is within the last few months that the first professor of dairying has been appointed in India.

Within the last fifteen years, the export to foreign countries of cows or female buffaloes from India has not exceeded 1,000 head per year (not including the cattle sent by the Military Department to Mesopotamia to supply milk to war hospitals during the war), and within that same period of 15 years it may be taken that the cow-feeding system of milk production in our four largest cities has caused the slaughter of not less than 250,000 young cows and female buffaloes. Cattle-breeding in India is not in a highly organized condition and the country cannot stand this drain. How can it be stopped ? No legislative measures are needed, but the

milk supply of our large cities must be organized on business lines and the milk produced under healthy conditions on the land where the cows will spend the whole of their natural lives. This milk must be pasteurized, cooled, and transported to the cities and sold there in proper sanitary packages by properly organized business units.

A city milk supply produced under this cow-feeding system cannot be a satisfactory one. The crowded lanes and back alleys of a great city not only militate against the production of clean milk of good quality, but it requires little argument to show that milk produced by cattle housed in the heart of a great city where land is worth rupees per square foot, where taxes are high and where the cost of labour, feed and water is a hundred per cent. over rural areas, must be expensive. It is very expensive, and therein lies the solution of both problems, *i.e.*, the untimely slaughter of young cows and the poor and expensive milk supply of our large cities. If public-spirited business men in India can be induced to take up the question of dairy farming and produce milk under natural conditions in suitable rural areas and offer such milk to the public in the large cities, they will be able to sell at such a price as the city cow-feeder cannot compete with and in a very short time drive this cow-feeding business out of existence, as has already been done in the other large cities of the world.

The milk supply of Calcutta and Bombay is not only the worst in existence, but it is the most expensive, and as an adequate supply of clean pure milk is an absolute necessity for the health of the community, the introduction of dairy farming methods and the transportation and sale of rurally produced milk in these cities not only is the best means of "cow protection" but, what is even more important, it is a sound method of "man protection" and will have a real effect on the health of generations to come.

The Calcutta Pinjrapole Society, it has been stated, spends some Rs. 1,50,000 per annum in prolonging, for a short period, the life of, say, a couple of thousand cattle, many of which have already

nearly reached the end of their natural existence. If the Indian merchants who support this society would put ten years' subscriptions into a soundly organized and properly equipped dairy farm, they not only would prevent the slaughter of, say, 2,000 young cows annually, but they would provide the citizens of Calcutta with cheap, clean, and pure milk, and at the same time earn for themselves a handsome dividend on their money.

WATER HYACINTH.

A SERIOUS PEST IN BENGAL.

BY

KENNETH McLEAN, B.Sc.,

Offg. Fibre Expert to the Government of Bengal.

WATER HYACINTH (*Eichornia crassipes*) is a native of Brazil and has now acclimatized itself throughout the Tropics. It is killed by severe frosts, hence the more temperate zones are free from the pest. The genus is called after a German Minister who lived at the end of the 18th century, so that it is probable that the plant first became known about that time. It would appear that its spread has been due to its beautiful flower and that it found its way into the gardens in different countries, to spread eventually all over the countryside.

In Florida, " admirers of the plant placed plants in the St. John's River in front of their houses to beautify the surroundings."

Water hyacinth first came to be seriously considered as a pest in Florida in 1890, in Queensland in 1895, in Cochin China in 1908, in Burma about 1913, and in Bengal in 1914. Its profusion in Eastern Bengal at the time of the outbreak of war was credited, in some districts, to the Germans, and it became known in localities as the " German Pana."

The plant is supposed to have been introduced into Eastern Bengal in 1910, but there is evidence that the plant had been growing in Eastern Bengal for many years prior to that date. Khan Bahadur Moulvi Hemayetuddin Ahmad of Barisal talks of having seen it in the *bhil* (swampy) tracts of Backergunge in his boyhood, and

Mr. A. L. Godden states that it is on record that the steamer conveying Sir John Woodburn through the *bhil* route in 1898 or 1899 was delayed whilst the weed was cleared away.

The Narayanganj Chamber of Commerce was instrumental in bringing the danger of the pest to the notice of Government in 1914.

In August 1917, there were very high floods throughout Eastern Bengal and these, apparently, were the means of carrying away much of the weeds to the sea, as in 1918 and 1919 the progress of the pest seemed to have a set-back. In 1920, however, and in the present year (1921), water hyacinth has spread very rapidly, and serious complaints have been received of its stopping navigation and destroying the deep-water paddy crops.

In districts where *khals* (water-channels) are the only means of travel, serious difficulties have arisen both through delays and the enhancement of rates by boatmen (Plate II). Several rivers are reported to have become impassable due to the weed, notably the Bhairab in the Nadia District and the Gorai which flows between Faridpur and Jessore Districts. Rivers with slow flowing currents are quickly blocked with the weed.

Life-history of water hyacinth.

The following description of water hyacinth will be found in the Pusa Bulletin No. 71—"Water Hyacinth: its value as a Fertilizer"—by Messrs. Finlow and McLean. The authors were indebted to Mr. H. G. Carter of the Botanical Survey for the description.

"*Eichornia crassipes,* Solms., belonging to the family ontederaceæ, is a native of South America but has now become a troublesome weed in other countries, notably Florida, Java, Australia and India. The plant is a herb which multiplies extensively by division of the root stock.

"When floating in water the plant has large bladder-like leaf-stalks which make it remarkably buoyant. The blade of the leaf acts as a sail, so that the plant, which multiplies very rapidly, is carried about on the surface of the water and soon becomes a pest.

Fig. 1. *Khal* choked with water hyacinth.

Fig. 2. Navigating a load of jute through hyacinth.

When growing in mud the bladder-like expansion of the leaf-stalk is absent. The plants bear spikes of ten or twelve handsome lilac flowers. The perianth is funnel-shaped and usually slightly irregular ; it ends in six lobes. The six stamens are inserted on the perianth. The ovary is superior and three-celled and has axile placentation. The fruit is a loculicidal capsule containing seeds with abundant mealy endosperm."

In the "Standard Cyclopedia of Horticulture" Wm. Tricker writes:—

"This genus includes the water hyacinth, the famous 'million dollar weed' that obstructs navigation in the St. John's River, Florida, and is a source of wonder and delight in every collection of tender aquatics in the North."............"About flowering time the plant sends down anchoring roots which, if the water be only 3 or 4 inches deep, penetrate the soil."................"The common water hyacinth sends out two kinds of roots, the horizontal ones often thick and fleshy, and apparently for reproductive purposes, the vertical ones long, slender and clothed with innumerable small horizontal fibres............"

The so-called horizontal roots should more properly be called "runners," special branches sent out for vegetative reproduction.

In neither of these descriptions is any reference made to the size of the plant, but in Bengal it has been found to attain a height of over 3 feet under favourable conditions.

It will be seen from the above descriptions that the plant in its own habitat is capable of reproducing itself both by seed and vegetatively. As regards propagation from seed, the following is taken from "Instructions for the eradication of the Water Hyacinth" issued by the Government of Burma in 1915 :—"When the flowers fade, the stem bends over in the middle immersing the seed pods in the water ; the pods opening, the seed escapes, seedlings form and in a few months themselves flower and send out runners."

No authority is quoted for this statement, but all attempts to germinate seed collected in Bengal have proved futile. Moreover, it was found that the number of flowers containing seed was small, only 1 per cent., and from a spike only one or two seeds were

obtained. The seed was tested for germination: (1) on dampened blotting paper, (2) in water, (3) in mud, and (4) in damp soil. The tests were made in February and the seed kept under observation for one month. The tests were made both under ordinary atmospheric conditions and in the incubator at a temperature of 86° F.

During the potash extraction experiments at Narayanganj in 1918-19 many thousands of the young plants were examined, but in every case showed evidence of having been detached from a parent plant.

The seed procured in Bengal appears to be perfectly formed and healthy. It may be noted that no seed could be found from plants growing in the red soil area.

The normal propagation in Bengal is by stolons or runners. These branch out from six to eight inches from the parent plant, forming on the end a rosette of small leaves. Roots spring out from the node where the rosette is formed and the young plant becomes self-supporting, and if the runner is broken floats away to continue propagation in another area. Those plants which continue attached to the parent plant also send out runners with the result that a matted mass surrounds the parent plant and individual plants are difficult to separate out. Water hyacinth is a perennial, and the death of the parent plant appears to be due to its being overgrown and submerged by its progeny.

In Circular No. 7 of 1919 of the Commonwealth of Australia it is stated that "the rate at which it grows has been a matter of careful observation, and a single root has in a few months covered a space of 600 sq. metres."

Mr. McSweeny, in conversation, stated that he had observed the growth from a single plant to cover 30 sq. yards in a few months in Assam. At Narayanganj, a tank from which the hyacinth had been taken out for the potash plant was found to be covered again with young growth in six weeks. In this case, however, no attempt had been made to clean the tank completely.

The bladder-like expansions of the leaf-stalk and the sail-like leaves are important assets to the plant in propagation. The former

enable it to float and the latter with the wind enable it to travel into new areas. This ability to travel is of very great importance in the spread of the pest and accounts for its spreading up-stream. In May of the present year the writer had an opportunity of seeing large masses of hyacinth being blown by the south wind up the Turag river. The writer and several independent witnesses estimated the rate at 3 miles an hour.

Operations against water hyacinth in Bengal.

The first steps regarding the spread of water hyacinth in Bengal were taken by the Agricultural Department as the result of a deputation from the Narayanganj Chamber of Commerce which waited upon H. E. Lord Carmichael and impressed upon him the danger to the waterways. Since this date, in 1914, the problem of combating the progress of the weed has been under the consideration, not only of the Agricultural Department, but also of District Boards and District Officers in different parts of the province.

The work of the Agricultural Department has been mainly concerned in finding out ways of utilizing the weed, whilst on the administrative side the problem has been the clearing and collection of hyacinth.

Utilization as manure. The Agricultural Department commenced an investigation into the possibilities of utilizing water hyacinth in 1914. The dried plant was found to be rich in potash and experiments were undertaken to arrive at the manurial value of both the rotted plant and the ash of the plant. With this object in view an extensive series of plots were laid down on the Dacca farm. The conclusions arrived at were published in the Pusa Bulletin No. 71 of 1917. These were, briefly, that the rotted plant is a valuable general manure slightly higher in value than cow-dung, and that the ash is several times richer in potash than wood ashes and therefore a valuable potassic manure. On the strength of these results cultivators were informed, through the agency of pamphlets and leaflets issued at different times, of the value of both the rotted hyacinth and the ash as manure.

This propaganda has had considerable effect as both the rotted hyacinth and the ash are used throughout Eastern Bengal as manure. There is, however, no doubt that the amount of hyacinth utilized in this way has had little effect in the reduction of the pest, as the cultivators take insufficient care in destroying the plants.

Extraction of potassium chloride. The high percentage of potash in the ash of the plant led the Fibre Expert to experiment on the possibilities of extracting potassium chloride. Prior to the war potassium salts had their chief source in the enemy countries, and on the outbreak of war prices soared high. Messrs. Shaw Wallace and Co. offered good prices for hyacinth ash, provided it came up to required standards as regards potash content, and arranged with middlemen for supplies. It was found that the ash arrived in such an adulterated condition as to make the extraction of the salt unprofitable and the firm lost money over the transaction. If the middlemen had played the game there would have been a large source of income, as the supply of potash salts both for munitions purposes and agricultural purposes was causing considerable concern to the Allies.

The process of extracting potassium chloride from the ash being a simple one, the Fibre Expert erected a small experimental plant at Narayanganj for the extraction of the salt. Mr. Basu, First Assistant to the Fibre Expert, describes this plant in the "Agricultural Year Book of the Department of Agriculture, Bengal, 1919." As a commercial adventure this plant proved unsuccessful but it was conducted under conditions which were adverse to success. Circumstances necessitated that labour had to be employed in collecting the hyacinth from tanks, carting it to the site of the extracting plant some considerable distance, drying it and burning it. In Narayanganj, moreover, labour is exceptionally expensive. A plant of this sort, situated in the vicinity of piles of the weed deposited by the elevator or grappler as in America, would probably show much better financial returns.

In 1920, the Collector of Dacca instituted a campaign against water hyacinth through the medium of the Panchayet Presidents,

introducing a "Hyacinth Day." In many Unions the work was taken up with a will, but the lack of enthusiasm on the part of neighbouring Unions disheartened the enthusiasts, whose land is again infected.

At a Panchayeti Conference held at Dacca on the 28th February, 1921, the effect of the order of the Collector was discussed and the opinions of the members who, as the Collector remarks, "have intimate experience of the evils of *kachuri* and of the possible ways of meeting these difficulties," are of great interest. The concensus of opinion of the meeting was that penalties should be imposed upon defaulters.

Failure to comply with the orders will always occur where no penalties are attached to non-compliance. In 1918 the Government of Bengal circularised all Commissioners and all public bodies including railway companies as to the necessity of taking steps to eradicate water hyacinth. A letter from the Agent, Bengal-Nagpur Railway, dated 12th December, 1919, is illuminating. He writes: "The whole of our borrow-pits between Howrah and Kharagpur and on other sections of the line outside Bengal were cleared this year at very considerable cost. It is now reported that practically nothing has been done by owners outside railway boundaries with the result that the borrow-pits on railway land have become re-infected and the work will have to be done again." The Agent of the E. B. Railway wrote in the same strain.

At a meeting of the Legislative Council, Bengal, a resolution was passed recommending to Government the appointment of a Committee "composed of official and non-official members under some scientific experts, such as Sir J. C. Bose or Sir P. C. Ray, to devise ways and means for removing the scourge of the water hyacinth and to combat it successfully, before any legislative action is taken, as recommended by the District Boards' Conference." In pursuance of the above resolution the present Committee under Sir J. C. Bose was appointed "to enquire into the spread of the water hyacinth in Bengal and to suggest measures for its eradication."

Operations against water hyacinth in other countries.

In the United States of America.

In the U. S. A. the plant first came to notice in the State of Louisiana in 1884 and in Florida in 1890. An interesting account, to which the writer is indebted for the following notes, will be found in "Lumbering and Woodworking Industries in the United States and Canada, Vol. III," by F. A. Leete, Indian Forest Service.

The Board of Engineer Officers constituted in 1897 to investigate water hyacinth recommended that systematic operations should be undertaken to keep waterways open for navigation. Operations on a large scale commenced in 1899 in both States. They began in each State on similar lines but subsequently developed on different lines, cattle owners in Florida instituting laws to prohibit the use of chemicals injurious to cattle.

Towing masses of the weed to sea. As the plant dies in salt water, drifting and towing the plant to the sea was first tried. Drifting to the sea was found to be the cheapest method of getting rid of the weed, but it is only possible where there is sufficient current. Surrounding masses of the weed with nets and towing them to the sea with a tow boat was found to be possible, but there was a leakage of plants *en route*, and this difficulty could not be surmounted and it was decided that towing would not be successful.

The erection of booms to confine the plant to restricted areas and to prevent it entering into back waters and channels which were required for navigation was found to be successful and is still a method in use. It has been found, however, that they are insufficient and attention has to be paid to the clearance of stray plants which find their way inside the channels.

Crushing the plant between rollers. Another method of destruction suggested by the Board of Engineers was the crushing of the plant between rollers mounted on a suitable vessel. The idea was given up as impracticable.

Solutions or mixtures fatal to the plant. An exhaustive series of experiments on the effects of spraying the plants with chemicals was commenced in 1906. The objects of the experiments were to find :—

(1) A solution or mixture fatal to the plant.

(2) Whether cattle would eat the plants with fatal effects after spraying.

(3) Whether anything could be added to make the sprayed plant obnoxious to cattle.

Of 23 different substances tried, only six were found to be effective in killing the plant. All six were found to be injurious to cattle. These six substances were :—

1. Fowler's Solution.
2. Sulphate of Copper.
3. Bi-carbonate of Potassium.
4. London Purple.
5. Arsenite of Lime.
6. Arsenite of Soda.

The first three were found to be too costly and the choice narrowed itself down to the arsenical compounds owing to their cheapness.

No substance could be found which would prevent the cattle from eating the plant.

Spraying water hyacinth in Louisiana. As noted above, spraying with chemicals is prohibited in Florida on account of the danger to stock but in Louisiana spraying is carried out on an extensive scale and is looked upon as a permanency. With three boats the District Engineer is just about able to keep pace with the growth of the plant. Complete eradication is considered impossible. Water hyacinth is found all over the State and much of the time of the boats is taken up in travelling backwards and forwards. The three boats used in the operations are the "Hyacinth," a stern wheeler specially built for the purpose, a Government barge, the "Chene," and a hired barge similar to the "Chene." The "Hyacinth" cost Rs. 1,20,000, but the cost of the other boats is not known. The "Hyacinth" carries tanks of

a capacity of 3,366 gallons and is fitted with a power sprayer capable of reaching 40 feet on each side of the boat, clearing a track of 80 feet. The area sprayed per day depends on how closely the hyacinth is packed, varying from 3½ to 10 miles by 80 feet.

The chemicals used are white arsenic (arsenious oxide) and soda (sodium carbonate). The usual strength is 1 in 10. On warm sunshiny days one gallon of the solution will destroy 10 square yards of closely packed hyacinth. On cloudy or cool days a larger quantity or stronger solution is necessary.

The recurring expenditure on spraying for 1917 is taken as Rs. 48,000, and the three boats sprayed an area of 5,021 acres. This works at a cost of Rs. 9-9 per acre, but in the statement given capital cost is not taken into account. Mr. Leete states that the cost per acre for the "Hyacinth" is Rs. 24.

Piling the hyacinth in heaps on the banks of rivers in Florida. Spraying being prohibited in Florida, mechanical piling has occupied the attention of the authorities in that State. In 1909 piling by means of an elevator was started and has been continued up to date. In 1916 a simpler contrivance called the "grappler" was tried and found very successful. The general idea of these contrivances is to lift the hyacinth out of the water and convey it to the bank of the river or channel where it is piled in heaps and allowed to rot.

Both the elevator and grappler are mounted on barges which are stationed near the bank, and the masses of hyacinth have to be dragged down to the site by means of ropes worked on windlasses. In the case of the elevator the plants are fed on to the foot of the elevator by men with rakes and they are carried by the elevator to the pile on the bank. The grappler works on a jib. It is dipped into the mass of hyacinth and, as it is raised by the engineer, mechanically grips a load of the plants. The jib is swung over to the bank where a man steers the grappler to the pile where the hyacinth is deposited.

The cost of clearing the hyacinth with the elevator is stated to be Rs. 33 per acre. No figures are given for the grappler which is still under experiment.

In Burma.

Construction of booms to collect hyacinth. In Burma instructions for the eradication of water hyacinth were first issued in January 1914 and revised instructions were issued in 1915. The instructions are confined to the erection of booms across the rivers and channels to catch the plants as they float down. The villagers are made responsible for the work, both for clearing the hyacinth from the banks above the booms and for dragging the masses of plants collected at the booms to the banks and burning them. Headmen of villages are empowered under the Burma Village Act (1907) to call out all able-bodied men, women, and children over the age of twelve to clear the hyacinth in their village tracts. Seemingly, the powers at the disposal of the authorities were insufficient, for in 1917 the Burma Water Hyacinth Act was introduced.

In Cochin China.

Construction of booms. It would appear that even before 1908 the prevalence of water hyacinth in the waterways was occupying the attention of the authorities in Cochin China, for Administrative Circular of Cochin China No. 12, 19th March, 1908, refers to previous orders on the subject. The order provides for the construction of booms to prevent the hyacinth from spreading into waterways not yet infected and for catching the masses of floating weed in the infected waterways so that they may be taken out of the water and piled on the banks. The plants must be heaped not less than 10 feet above high water-mark and, when sufficiently dry, burnt. With this object, during the first three days of each month or more often, if necessary, proprietors, farmers, and small holders must ensure the removal and destruction of plants within their holdings. The application of the order seems to have raised objections from some Administrators as in his Circular No. 29 of 27th January, 1911, the Lieutenant-Governor

sets these objections aside and insists on more strenuous measures, and mentions the appointment of river overseers to organize the destruction of water hyacinth.

In his Circular No. 147 of 26th June, 1911, the Lieutenant-Governor remarks on the success of the 500 embankments already established and proposes the extension of the scheme. From his concluding remarks it would appear that the obligations placed upon proprietors to destroy hyacinth on their land had been withdrawn.

In Australia.

Dredging in still water and floating to the sea in currents. Water hyacinth was known in New South Wales as early as 1895, and mention is made of 7½ acres of the weed in the Wollondry Lagoon having to be cleared at a cost of £8 (Rs. 120) in 1900. Mechanical collection of the weed with an outfit somewhat similar to the elevator used in America was found successful in the Bremer river. As in America the masses of weeds were towed up to the outfit. After the clearing, stray weeds along the banks were cleared up by men working from flat-bottomed boats. Where tidal currents prevailed the hyacinth was allowed to float down with the out-going tide and prevented from returning by the erection of booms at the turn of the tide. These operations have met with success in the two rivers, the Bremer and the Brisbane, where they were put into effect. Mr. E. A. Cullen, the Engineer for Harbours and Rivers, Brisbane, reports : " The rivers named at one time were covered almost entirely for 30 miles, so that motor boats could not pass, and steam lighter traffic was almost stopped. By the means adopted, *i. e.*, dredging the weed out in the relatively still water areas and drifting it down to salt water where tidal currents prevailed, the rivers are entirely cleared. An annual inspection and clean up of any few small patches occurring has kept the waters clean for several years at a cost of under £50 per annum."

Mechanical collection of the hyacinth and the manufacture of potash from the collected heaps is under contemplation in other parts of Australia.

Legislation against proprietors and tenants who fail to destroy water hyacinth growing on their land or adjacent waterways.

Legislation in Cochin China.

Attempts were first made in French Cochin China to legislate against people failing to destroy water hyacinth in 1908. The law then introduced not only required that all hyacinth should be destroyed, but also made landlords and tenants responsible for the construction and maintenance of barriers across the waterways for collecting weed floating down-stream. The law further stipulated that the work of clearing should be done during the first three days of every month. In the event of a proprietor failing to carry out his obligations, the district officers were empowered to do the work for him. The penalties of non-observance of the law are, unfortunately, not intelligible.

Provision is made in the orders empowering Chief Administrators to relax the law in certain cases and, as the Lieutenant-Governor mentions that objections were raised by his Administrators and in a subsequent circular mentions the withdrawal of the obligations placed upon proprietors, it appears that the Act was difficult to apply. The Director of the Scientific Institute, Saigon, in 1921 remarks that "the regulations issued in 1908 have not been applied with sufficient rigour to enable an estimate of their efficiency to be arrived at."

The Burma Water Hyacinth Act, 1917.

In 1917 the Burma Water Hyacinth Act was introduced. In this Act the presence of the water hyacinth is declared to be a public nuisance in Burma, and any person who possesses or keeps the water hyacinth or fails to destroy it in accordance with such notice as may be served upon him shall be guilty of an offence and shall be liable on conviction thereof to a fine not exceeding Rs. 100 or upon a second or subsequent conviction to a fine not exceeding Rs. 500. The Local Government may make rules prescribing the method by which and the time within which the destruction of the

water hyacinth shall be completed and prescribing the form and the terms of the notice to be served.

From the Administration Reports it appears that the Burma Government is also finding the Act difficult to apply.

Dacca District Board By-Law.

In 1919, the District Board of Dacca introduced a by-law to legislate for the disposal of water hyacinth. The by-law reads as follows :—

"31 B. Any person having possession of, or control over, any land or water on or in which there exists any water hyacinth shall, if so required by a notice in writing signed by the Chairman or Vice-Chairman of the District Board, a Local Board or a Union Committee or by the District Engineer, destroy or remove such water hyacinth within the period mentioned in such notice. Provided that such notice (*a*) shall be issued simultaneously for the whole of an area to be defined by the District Board, a Local Board or Union Committee, and bounded by rivers or large *khals*, and (*b*) shall not be issued oftener than once a year."

The penalty attached to a breach of the by-law is a fine up to a maximum of ten rupees.

An additional by-law was proposed in November 1920, but it was not approved by Government. It read as follows :—

"31 D. If the person upon whom notice has been served under by-law 31 B fails to carry out the order as required by the said notice, he will be liable to pay such costs as are incurred by the District Board, Local Board, Union Board, or Union Committee in order to remove or destroy the water hyacinth. Such costs will be recovered as other dues to those bodies are."

By-law 31 B fails in that it only stipulates that the hyacinth should be cleared once in a year. Experiments in tank clearing conducted by the Agricultural Department have shown that at least two clearings are necessary within a short interval as there are generally a number of plants missed in the first clearing.

At a meeting of representatives from District Boards held at Dacca in the beginning of this year opinion was against the

practicability of local legislation. One district is infected from another and it is difficult to impose penalties on individuals who can claim that the land was infected from up-stream. It was agreed that District Boards were powerless unless an Act on the lines of that introduced in Burma be introduced to apply to all India.

The subject was further discussed at a meeting of representa tives from all the District Boards in Bengal held in Calcutta in January 1921. A resolution was passed urging upon Government the necessity of passing an Act similar to the Burma Act. This induced Babu Nibaran Chandra Das Gupta to introduce a resolution in the Legislative Council regarding the appointment of the Water Hyacinth Committee, his contention being that Government could not penalize a man for not destroying water hyacinth until he had been shown the ways and means of destroying it.

PRACTICAL SUGGESTIONS REGARDING COLLECTION, DESTRUCTION AND UTILIZATION.

Present methods of collection.

Bengal has not, so far, shown much in an original line in the way of method of collection, and this has been done by hand labour in all cases. In some cases the District Boards have allotted funds to pay labourers to clear waterways and in other cases cultivators and others have been stimulated to the task by warnings as to the danger to their crops and communications. The value as a manure has been an incentive to cultivators to collect the hyacinth in heaps until it rots and then to apply it on their land.

The elevator and grappler.

It will be seen from the note on measures taken in America that mechanical collection is advocated there. The two machines in use are the elevator and grappler, and there are many waterways in Bengal where the system employed in America would apply. These machines would be of importance if it were decided that

part of the money spent in destroying the hyacinth should be recouped by utilizing the plant for commercial purposes.

The present laborious method of clearing waterways and tanks by hand could be considerably lightened by the use of weed cutters and pond cleaners of which there are several on the market.

The erection of stoppage booms where plants floating down waterways may be checked and collected may also reduce labour and concentrate the work.

Present method of destruction.

Two methods of destruction are common in Bengal and both depend upon the plants having been first brought to dry land. The one is burning the plants after they have been dried and the other is rotting the plants in pits. Both are efficacious as long as no green plants are left to spring to life when the rains come. The majority of cultivators, when they are troubled with hyacinth on their land, just push it into the rivers. They may hope that it will reach salt water and there die, but it is generally destined to infest a neighbour's fields further down-stream.

Killing the plant by spraying solutions.

In America the spraying of the masses of floating plants with arsenical compounds has been accepted as the only method of killing the weed and keeping it in check. Objections have been raised to the danger of using poisons, and in Bengal, where every waterway is not only used by stock but also by the human population for washing and drinking purposes, the use of arsenical solutions becomes impossible.

Turning to the utilization of water hyacinth, the value of the plant as a manure and as a source of potassium chloride has already been discussed.

Manufacture of paper from dried water hyacinth.

The manufacture of paper from the dried hyacinth has lately been experimented upon in the Fibre Expert's laboratory. The samples of paper produced are promising, but as the percentage of pulp to dried plant is only 25 per cent. the value of water hyacinth

for paper making commercially is doubtful, unless it makes up into a special type of paper as the experimental samples suggest. In this connection the opinion of a leading paper manufacturer in England is quoted in the Commonwealth of Australia Circular No. 7. He reported on samples of water hyacinth sent to him that "it was the most inferior substance yet offered to him."

Preparing ink from the flowers.

In 1918 the Subdivisional Officer, Brahmanbaria, reported that blue-black ink had been prepared from the flowers of water hyacinth and that the colour changed to majenta red on treatment with acid and from red to green on treatment with soda. No method could be found of keeping the colours fast, and nothing further has been heard of the process.

Fodder for cattle.

The utilization of the green plant as cattle fodder is a common practice throughout districts where water hyacinth is plentiful at times when there is a scarcity of grass. The plants are pulled out of waterways and tanks and placed before the cattle in heaps. As far as has been observed the plants are not dried and preserved for fodder purposes. When grass is scarce, or in towns where the available grazing is liable to be fouled, it is a common sight to see the cattle wading into the tanks to graze on the hyacinth.

Utilization as fuel.

Many cultivators utilize the dried hyacinth for fuel. At the beginning of the cold weather the hyacinth is pulled out of their fields and the adjacent waterways, left on the high land to dry, and when dry used along with jute sticks and refuse as fuel. The ashes are subsequently used as manure.

Utilization in other countries.

Investigations into the possibility of putting water hyacinth to commercial use have been undertaken in other countries but do not bring any further enlightenment to bear on the subject. The various suggestions put forward have all proved to be of no

commercial value except its utilization as a source of potash. In Cochin China numbers of attempts were made to utilize the weed, amongst others the construction of furniture, the manufacture of ropes, and the manufacture of bags. These attempts were unsuccessful and it was concluded that its chief value was as a manure on account of the high percentage of nitrogen it contained. In New South Wales, paper manufacturers reported that it could only be used for straw-board and that sufficient other raw material was already available at 10*s*. a ton. Samples were supplied to firms of upholsterers who either condemned it or reported that it was only of use for the cheapest lines of upholstering, and would have to be marketed at a cheap rate. The Commonwealth of Australia Circular No. 7 of 1919 mentions an inventor who is patenting a process for the extraction of potash from water hyacinth in New South Wales. This process might be worth consideration.

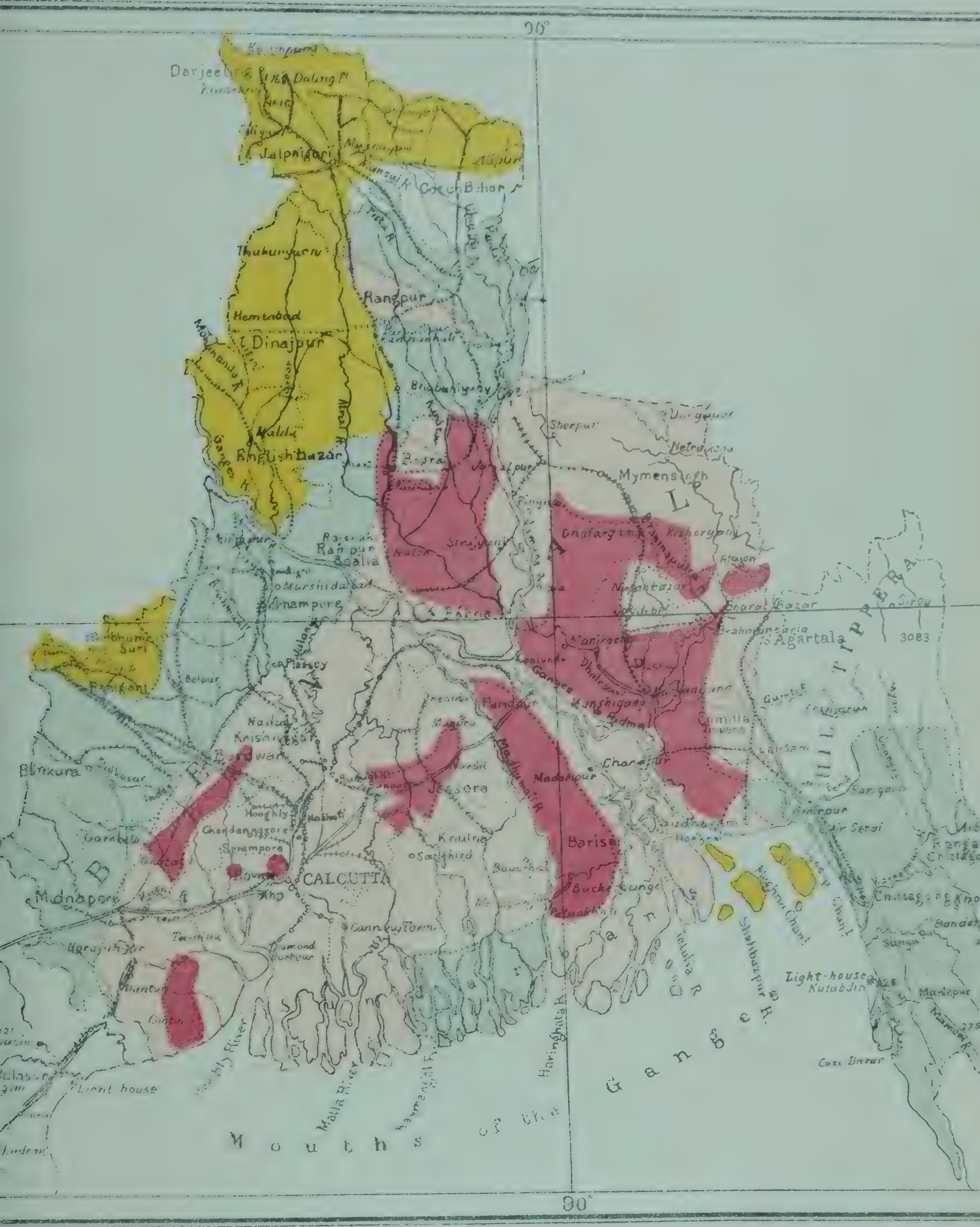
Conclusion.

A glance at the attached map of Bengal (Plate III) will convince one of the dangers of the water hyacinth invasion in Bengal. The eastern part of the province with millions of acres over-flooded during the rainy season is especially susceptible to the pest. At the beginning a troublesome weed in the waterways, water hyacinth has now become a menace to the crops, and unless immediate steps are taken to eradicate it or at least to prevent its further spread, the whole of the deep-water paddy crop in Bengal will be endangered.

The reduction of the cost of eradication by utilization of the weed appeals to the economist. The danger lies in that the weed may not be properly destroyed if it obtains a commercial value, and that plants not destroyed will continue to spread the evil.

Nothing short of the complete destruction of the plant will save Bengal from this disastrous pest, and the findings of the Committee which is at present sitting in Bengal are awaited with interest. It is hoped that the recommendations will be put into immediate effect as it is felt that there has already been too much delay in tackling this vital problem.

MAP OF BENGAL
SHOWING THE AREAS AFFECTED BY
WATER HYACINTH.



Areas reported as very seriously affected.

Areas reported as less seriously affected.

Areas reported to contain weed in tanks, etc.

A PRELIMINARY NOTE ON THE INCREASE OF GRAPE YIELD.*

BY

S. H. PRAYAG, M.Ag.,

Of the Department of Agriculture, Bombay.

In parts of Western India, and more especially in Nasik which is the chief grape-growing centre in the Bombay Deccan, the variety most common and prolific in yield is what is called *bhokri*. This variety, though much in demand on account of its availability and cheapness in the markets of Poona, Bombay, Nasik and Ahmednagar, is not, however, so fine and sweet as the varieties *fakadi* and *pandhari-sahebi* which are considered to be superior ones. Though the fruits of these fetch a better price, nearly twice as much as that of the local variety, their cultivation has not been on the increase, due chiefly to their extremely shy bearing nature. The question therefore arose early in 1914, as to how these varieties could be improved so as to be of commercial importance. Attempts were made to increase their yield, as well as the yield of the local variety *bhokri*, in the Ganeshkhind Botanical Garden, and the following is a résumé of the work done and the results obtained.

Methods of training as factors in influencing the yield.

The grape-vine requires some sort of training as it will not bear well if it lies on the ground. Various systems of training have therefore been adopted according to the fancy of the grower and the custom of the locality. The usual system of training

* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

adopted by Nasik cultivators is that on single-stake. In this system each vine is trained to a *pangara* plant (*Erythrina indica*) which forms a good living support (Plate IV, fig. 1). In Junnar (District Poona), the vine is surrounded by four *pangara* plants and is allowed to have four arms, each arm being trained to a *pangara* plant. This method is known as the Junnar method. The following are some figures of yield from plants in the Ganeshkhind Garden trained on these two methods :—

System of training	Name of the variety	Total No. of plants	No. of bearing plants		Total yield		Average yield per bearing plant	
			1919	1920	1919	1920	1919	1920
					lb. oz.	lb. oz.	lb. oz.	lb. oz.
Single-stake	Bhokri	69	56	49	302 2½	209 15	5 6·3	4 4·5
Junnar ..	Do.	31	20	23	208 12½	95 13	10 7·0	4 2·6

Average yield per plant in the single-stake system for two years is 4 lb. 13·4 oz.

Average yield per plant in the Junnar system for two years is 7 lb. 4·8 oz.

In the Junnar system, the plants had been planted at the same distance as that in the single-stake system, *viz.*, 9 feet apart each way.

The Junnar method, though slightly better than the single-stake system as regards yield, entails a good deal of manual labour, as ploughing and other interculturing operations cannot be performed by bullock-power on account of the space being occupied by *pangara* plants. Other methods of training were started by Mr. G. B. Patwardhan, B.Sc., Assistant Professor of Botany, Agricultural College, Poona, from 1913, and these were (1) Umbrella, (2) Overhead and (3) Kniffin.

Umbrella system. In this system, the vine is trained to a strong wooden support in the centre, of the height of 6 feet, from the top of which several cross-bars pass at an angle of about 45° with the central support and are nailed down to four supports at the corners, the whole thus presenting the form of an umbrella

PLATE IV

Fig. 1. Bhokri grape-vine trained on the single-stake system.

Fig. 2. Bhokri grape-vine trained on the umbrella system.

(Plate IV, fig. 2). Only six plants of *bhokri* variety had been so trained. The following are some figures of yield :—

Variety Bhokri : Umbrella system of training.

Plant No.	Age of the plant	Year of bearing	Total No. of bunches	Total yield	Remarks
				lb. oz.	
158	4th year ..	1916	78	19 13	
	6th ,, ..	1918	43	10 14	
	7th ,, ..	1919	63	16 10½	
	8th ,, ..	1920	132	13 8	Bunches were small in size.
168	4th ,, ..	1916	133	40 7	
	6th ,, ..	1918	70	14 0	
	7th ,, ..	1919	198	66 11	
	8th ,, ..	1920	8	2 1	Badly attacked by *Anthracnose.*

Average yield of plant No. 158 for four years is 15 lb. 3 oz.

Average yield of plant No. 168 for four years is 30 lb. $12\frac{3}{4}$ oz.

Variety Bhokri : Single-stake system of training.

Plant No.	Age of the plant	Year of bearing	Total No. of bunches	Total yield	Remarks
165	5th year ..	1916	20	7 8	
	7th ,, ..	1918	4	7 2	
	8th ,, ..	1919	35	9 12	
	9th ,, ..	1920	3	0 10	
145	5th ,, ..	1916	40	8 1	
	7th ,, ..	1918	7	4 0	
	8th ,, ..	1919	29	7 0	
	9th ,, ..	1920	27	5 5	

Average yield of plant No. 165 for four years is 5 lb.

Average yield of plant No. 145 for four years is 6 lb. $1\frac{1}{2}$ oz.

The following shows the comparative yield of the two systems :—

Variety Bhokri.

System of training	Total No. of plants	No. of bearing plants		Total yield		Average yield per bearing plant	
		1919	1920	1919	1920	1919	1920
				lb. oz.	lb. oz.	lb. oz.	lb. oz.
Single-stake ..	69	56	49	302 2½	209 15	5 6·3	4 4·5
Umbrella ..	6	6	6	222 1	53 2	37 0	8 13·6

From the above, it is clear that the umbrella system of training has given decidedly better results than the local system. It remains,

however, to be seen how far this system could be adopted on a field scale.

Overhead system. In this system, four canes of each plant are extended each in a different direction until they meet with the canes of the neighbouring plant. From each of these canes short spurs are developed, thus giving more room for the development of flowers and fruit. The following shows the comparative yield :—

Variety Fakadi.

System of training	Total No. of plants	Total yield	Average yield per plant	Amount of space covered by the plant
		lb. oz.	lb. oz.	3,267 sq. feet.
Single-stake ..	48	60 1¾	1 4	
Overhead ..	48	170 2¼	3 8¾	,, ,,

Thus for the year 1920, the experiment has given definite results in favour of the overhead system of training, the average yield per plant being thrice as much as that on the single-stake system. Further results are, however, awaited before definite conclusions could be arrived at.

A slight modification of this system was adopted in the case of *pandhari-sahebi* variety which is a more vigorous grower than *fakadi.* The usual method of pruning adopted in previous years in this variety was the method of spur-and-renewal-spur. In October 1919, an experiment was started by the writer to keep the long canes formed during the rainy season after April pruning and prune them at their further end, *viz.*, after leaving 10 or 12 buds, instead of pruning them after 2 or 3 buds. The following are the results obtained :—

Variety Pandhari-sahebi : Age 7 years.

Method	No. of plants treated	Total yield	Average yield per plant
		lb. oz.	oz.
Spur-and-renewal-spur ..	17	3 8	3·2
Long spur	18	15 6½	13·6

The results, though they are of one year, show in favour of the long-cane system. Maney says[1]: "Grape-pruning experiments carried on near Council Bluff's during the season of 1914, for a comparison of the spur with the long-cane and renewal-spur system, showed that the vines pruned after the long-cane system yielded, on the average, 41 per cent. more grapes than the spur pruned vines. These results indicate that the long-cane system is of value for the south-western and other sections of Iowa where grapes are grown." However, it must be recognized that these results are for one year only. Further experiments with the two systems must be carried on before the long-cane system can be recommended unreservedly.

Kniffin's or drooping system. This system, named after William Kniffin of Clintondale, consists in training the vine to posts, six feet in height, set by each vine. Two wires or horizontal bars are fixed, the one about three and a half, the other about six feet from the ground. One main stem is grown from the ground to the upper wire. Only two branches are allowed on each wire, one on each way, the rest being removed. Four arms are thus encouraged and these are firmly tied to the wire and are extended to a length of 3 or 4 feet until they meet with their neighbours. Any shoots springing from each bud are allowed to hang down with their clusters of growing grapes. This method is much in practice in America and is said to have a distinct merit for strong growing varieties. It was adopted in the Ganeshkhind Botanical Garden, Kirkee, in the year 1912. The following statement shows some outturn statistics :—

System of training	Name of the variety	Total No. of plants	No. of bearing plants		Total yield		Av. yield per bearing plant	
			1919	1920	1919	1920	1919	1920
					lb. oz.	lb. oz.	lb. oz.	lb. oz.
Single-stake ..	Bhokri	69	56	49	302 2½	209 15	5 6·3	4 4·5
Kniffin ..	,,	12	11	4	184 9	10 15	16 12	2 11·5
Single-stake ..	Fakadi	48	14	27	97 10½	60 1¾	6 15	2 3·7
Kniffin ..	,,	16	13	15	76 10	36 1	5 14	2 6·4

[1] *Agri. Expt. Stn. Iowa Bull.* 160, Oct. 1915.

This system has not shown any decided advantage over the local system of training except in the year 1919, when the average yield of a *bhokri* plant was nearly three times as much as that on the single-stake system.

STUDY OF THE POLLEN AND METHODS OF RINGING AND COILING IN INCREASING FRUITFULNESS.

Apart from the methods of training adopted, other lines of increasing the grape yield were carried out. In the varieties noticed in the Ganeshkhind Botanical Garden, Kirkee, two classes of grape clusters were seen to exist, *viz.*, (1) clusters with closely set fruits and (2) clusters with berries set wide apart (Plate V, figs. 1 and 2). It was at first suspected that, in the loosely set clusters, the flowers may be sterile.

This self-sterility (entire or partial) was studied by Professor Beach. He says[1] : " Many of the cultivated varieties of American grapes are either self-sterile or very imperfectly self-sterile. In discussing the practical bearing of these discoveries upon the selection of varieties and arranging them in vine-yards so as to get the best results in fruit production, attention was called to the fact that self-sterile varieties may produce well-filled clusters of fruit when the vines are located near enough to other kinds to make cross-fertilization possible." The subject was further studied by Mr. Booth who states[2] : " (*a*) The self-sterility which is known to exist among many varieties of cultivated grapes is, in many cases, if not all, due to a lack of potency in the pollen. (*b*) This lack of potency is indicated in the pollen grains by a shape which is quite different from that of potent pollen. (*c*) Certain varieties of grapes bear pollen in which both the potent and impotent forms are mixed." He further states : " The self-sterile grains seemed to be surrounded by a mucilaginous substance which makes them stick to one another more or less so that the pollen whether it lies dry on

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[1] *New York Agri. Expt. Stn. Bull.* 157.
[2] *New York Agri. Expt. Stn. Bull.* 224.

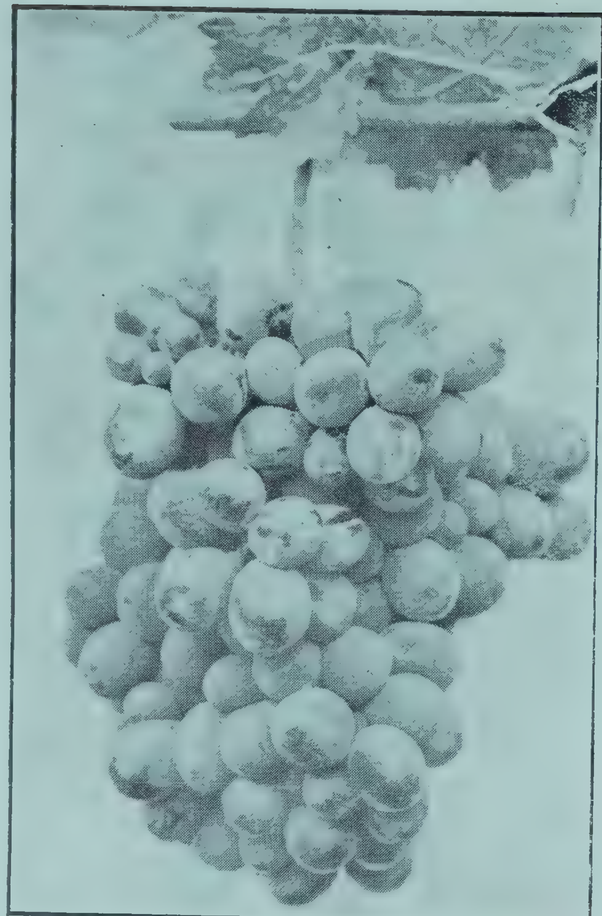

Fig. 1. Closely set bunch of grapes; variety Bhokri.

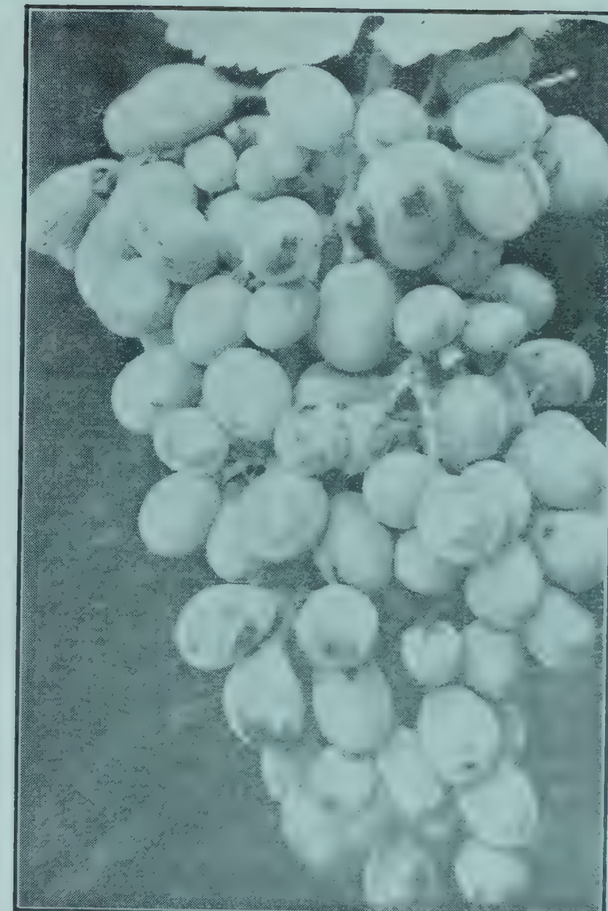

Fig. 2. Loosely set bunch of grapes; variety Pandhari-Sahebi.

Fig. 3. Coiling of grape-vines to stimulate the buds.

the slide or is placed in liquid media arranges itself in a succession of clumps. This mucilaginous substance does not appear to be soluble in water, as the pollen grains retain their respective positions even after several days in the solutions. The self-sterile pollen, on the other hand, shows no such arrangement but the grains distribute themselves either on the slide or in the liquid like so much dry powder, quite by chance. The self-fertile forms are oblong, blunt at the ends and quite symmetrical. The self-sterile sorts are quite different in shape, being more irregular and usually more pointed than those of the other class."

I set to work on the lines suggested above in November 1919, but my laboratory examination of the dry pollen grains did not reveal any characteristic differences in the size or shape of the different classes of pollen. As the blooming season of the grape is very short, my observations were, moreover, limited.

At the present stage it may fairly be said that the flowers of varieties existing in the Ganeshkhind Botanical Garden were not found to be self-sterile. Other attempts, therefore, of improving the yield adopted in foreign countries, *viz.*, girdling or ringing and coiling the branches had to be adopted.

Girdling. This consists in the removal of a ring of bark to a width of half to one inch. The principle of this is to concentrate a large amount of elaborated food material in the portion of the branches situated above the ringed area and thus stimulate them to bear flowers and fruits. It is practised by the Greeks to promote setting of fruit, uniformity of bunch, and increased size of berry.[1] In the work done by the writer, a narrow ring of bark to a width of $\frac{1}{2}$ to 1 inch was taken from the fruiting canes of the *pandhari-sahebi* variety between the first and second nodes. The operation was done immediately after pruning on October 22, 1919, and also when the leaves had appeared, *viz.*, on 18th and 19th November, 1919.

[1] *Garden and Field* Australia, cited in *Pac. Coast Fruit World,* May 24, 1901.

Besides the above, the operation of coiling the canes was also done. This is usually done, in the Ganeshkhind Botanical Garden, in the case of grape plants on bowers and has become an annual operation (Plate V, fig. 3). It had not however been done on the shy bearing varieties. In order to ascertain its efficacy on the *pandhari-sahebi* variety, the canes were severely coiled so as to form two or three circles and firmly tied in position by means of a string. The following shows the results obtained :—

No.	Nature of the operation	No. of shoots treated	Yield	
			lb.	oz.
1	Coiling the canes	43	6	6½
2	Ringing the spurs immediately after pruning ..	38	0	5
3	Ringing the spurs when new growth had formed ..	34	0	8
4	Long rods kept	36	8	1

Though the above are the results of one year's trials, they indicate that ringing even before or after the formation of leaves failed to give good results in the case of the variety *pandhari-sahebi*.

Influence of stock on the yield.

Mr. H. V. Gole, the well-known grape grower of Nasik, tried the grafting methods and has found that *fakadi*, when grafted on *bhokri*, yields 2 lb. more than the average yield on its own roots.[1]

The experiments conducted in the Ganeshkhind Botanical Garden are inconclusive.

Yield in relation to manuring.

In order to ascertain the efficacy of some manures in increasing the grape yield, experiments were started in the Ganeshkhind Botanical Garden, Kirkee, in 1912.

[1] *Agri. Jour. India*, XIV, pt. I.

Variety Bhokri : treated in Oct.-Nov. 1912.

No.	Manure given per tree in one dressing	No. of plants treated	No. of bearing plants	No. of bunches	Total wt. of bunches		Yield per bearing plant	
					lb.	oz.	lb.	oz.
1	Fish manure 8 lb. .. Sulphate of potash 1 lb. ..	6	6	28	9	3	1	8½
2	Fish manure 8 lb. ..	6	6	13	3	12	0	15
3	Farmyard manure 20 lb. ..	6	4	10	2	13	0	11¼
4	Safflower cake 8 lb. .. Sulphate of potash 1 lb. .. Bonemeal 2 lb. ..	6	4	21	3	8	0	14
5	Safflower cake 8 lb. .. Bonemeal 2 lb. ..	6	6	39	13	1	2	3
6	Sheep dung 20 lb. ..	6	6	17	4	2	0	11
7	No manure ..	16	6	17	3	14	0	10

The plants were planted in February 1911, *i.e.*, the fruiting above referred to occurred when they were just two years old and was not therefore up to normal.

The results of 1912 showed in favour of treatments 1 and 5, and hence these two were selected for experiment in 1913 against farmyard manure by itself.

Variety Bhokri : manured October 1913.

Manure given per tree	No. of bearing plants	Total yield		Yield per bearing plant		Yield per bearing plant' 1912-1913	
		lb.	oz	lb.	oz.	lb.	oz.
Farmyard manure 80 lb. ..	23	61	0	2	10½	0	11¼
Fish manure 8 lb. .. Sulphate of potash 1 lb. ..	23	72	0	3	2	1	8½
Safflower cake 8 lb. .. Bonemeal 2 lb. ..	28	55	13	2	0	2	3

As the flowers appeared soon after pruning, it was found doubtful if manures applied in October really affected the amount of

flowering. Hence it was decided in 1914 to apply manures *after the April pruning* so that they may be effective in producing strong bearing wood for the next season.

Variety Bhokri: manured April 1914.

Manures given per plant	No. of plants (bearing)	Total yield	Yield per plant
		lb.	lb.
Farmyard manure 80 lb.	25	159	6·4
Fish 8 lb. and sulphate of potash 1 lb. ..	25	199	8·0
Safflower cake 8 lb. and bonemeal 2 lb. ..	25	154½	6·2

The two years' results show in favour of a combination of fish manure and sulphate of potash.

Conclusions.

The following conclusions are arrived at :—

(1) The umbrella system has so far been found to give better yield than others in the case of *bhokri* variety. It remains yet to be seen how far this system could be adopted on a field scale.

(2) In the year 1919-20, the overhead system of training has given three times as much yield per plant as that on the single-stake in *fakadi* variety, the amount of space occupied being the same in each case.

(3) The Junnar system has given a better yield than the single-stake system but entails a good deal of manual labour.

(4) Examination of the pollen grains of *fakadi* and *pandhari-sahebi* variety did not show the characteristics noticed in the flowers of partially sterile varieties in America.

(5) Among the manures tried, a combination of fish manure and sulphate of potash has given favourable results.

PLATE VI.

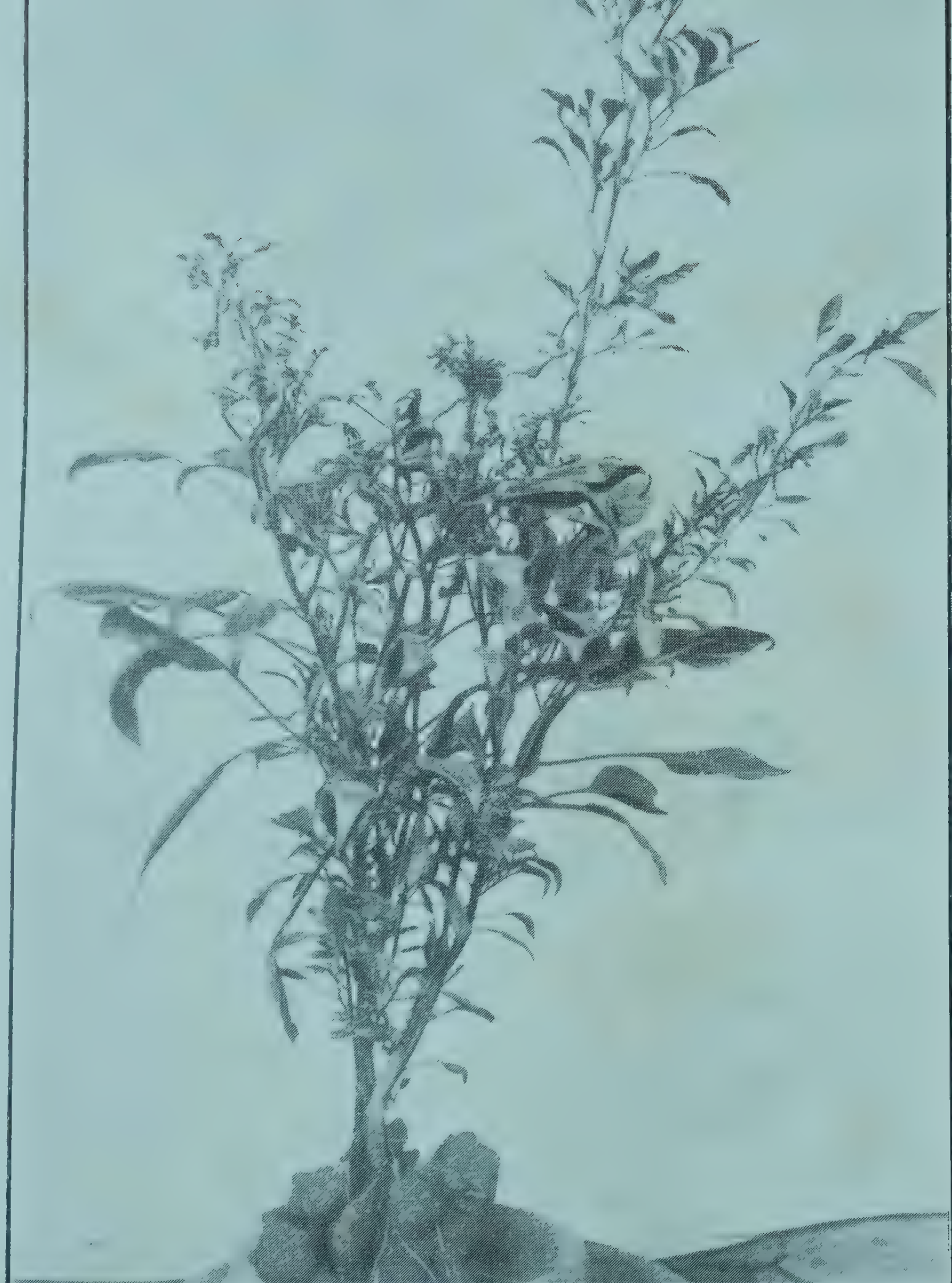

Fig. 1. A chilli plant attacked by the *murda* disease.

Fig. 2. Zinnia plants attacked by the chilli mite.

THE "MURDA" DISEASE OF CHILLI (*CAPSICUM*).*

BY

G. S. KULKARNI, M.AG.,

Assistant Professor of Mycology, Agricultural College Poona.

THIS is a very serious disease, nay, in fact the greatest enemy of the chilli plant, occurring in most parts of the Bombay Presidency. It is, therefore, well known to the cultivators who call it by various names as *murda*, *goja*, *macoda* and *mirya* in the Deccan, *chandiroga* or *mutlagariroga* in the Karnatak, and *kokadva* in Gujarat.

The disease makes its appearance first in the terminal or axillary tender shoots of the plants. The leaves of the attacked shoots get curled up usually outwards and droop down (Plate VI, fig. 1). Often they show much distortion and wrinkling and are reduced in size. They gradually dry up and drop down. New shoots come up, which are in turn attacked and destroyed. The growth of the plants is thus checked. The disease appears at any stage of the plant. If it begins at the seedling stage the affected plants never produce any flowers and fruits. If the plants are attacked in the flowering stage most of the diseased flowers wither and drop down and the few that escape form berries which are also soon spoiled. The attacked fruits are much smaller than the normal ones and are curved. The disease gradually spreads to the lower branches, and as the internodes of the attacked branches are shortened the leaves appear as if they are in clusters and are reduced to minute scale-like structures. In such a highly malformed stage the plant at times is

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* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

recognized with great difficulty. Such a severe attack was noticed this year (1920) near Poona in the Baramati valley where in most of the fields the crop was a failure. Reports of ravages of this disease have also been received from the tracts of Bijapur, Gokak, Kolhapur, Khed, Amalsad and Anand.

The cause of this disease is the same mite which causes the *tambera* disease of potato.[1] That the potato mite has something to do with the chilli trouble was suspected by the writer while the *tambera* disease was being studied in the year 1919, but an attempt to produce the disease in chilli plants by inoculation experiments was not successful as mentioned in the previous paper, probably because the experiments were done rather late in the season. The study was therefore postponed for the next year. Early in June 1920, the disease was noticed on the chilli seedlings in the writer's compound, and an examination of the diseased plants gave clear proofs of the presence of a mite agreeing in all its stages with that on potato. Inoculation experiments were therefore at once started. Three sound, twenty-days-old potato plants in pots were taken. Two were used for inoculation and the third for control. Inoculation of the plants was made by putting on them affected parts of the chilli plants containing the mites. The infected plants began to show on the ninth day distinct symptoms of attack, *viz.*, the twisting and curling of the leaves with a reddish tinge and the erect bunching habit of the shoots (Plate VII, fig. 1), and on the thirteenth day the tender leaves on one plant began to dry up; on the sixteenth day the affected shoot was completely killed. The control plant remained healthy during this period. Experiments were then made with chilli plants which were inoculated with the potato mite. Six sound chilli plants in pots were chosen, four for inoculation and two for control. Inoculated plants on the 12th day began to show the typical symptoms of the *murda* disease. The leaves became twisted and crumpled, were much reduced in size and had a number of moving mites on them. The control plants remained quite healthy all the while.

[1]Mann, Nagpurkar and Kulkarni. The *Tambera* Disease of Potato. *Agri. Jour. India*, XV, pt. III.

Fig. 1. Potato plants showing the *tambera* disease when inoculated with the chilli mite.

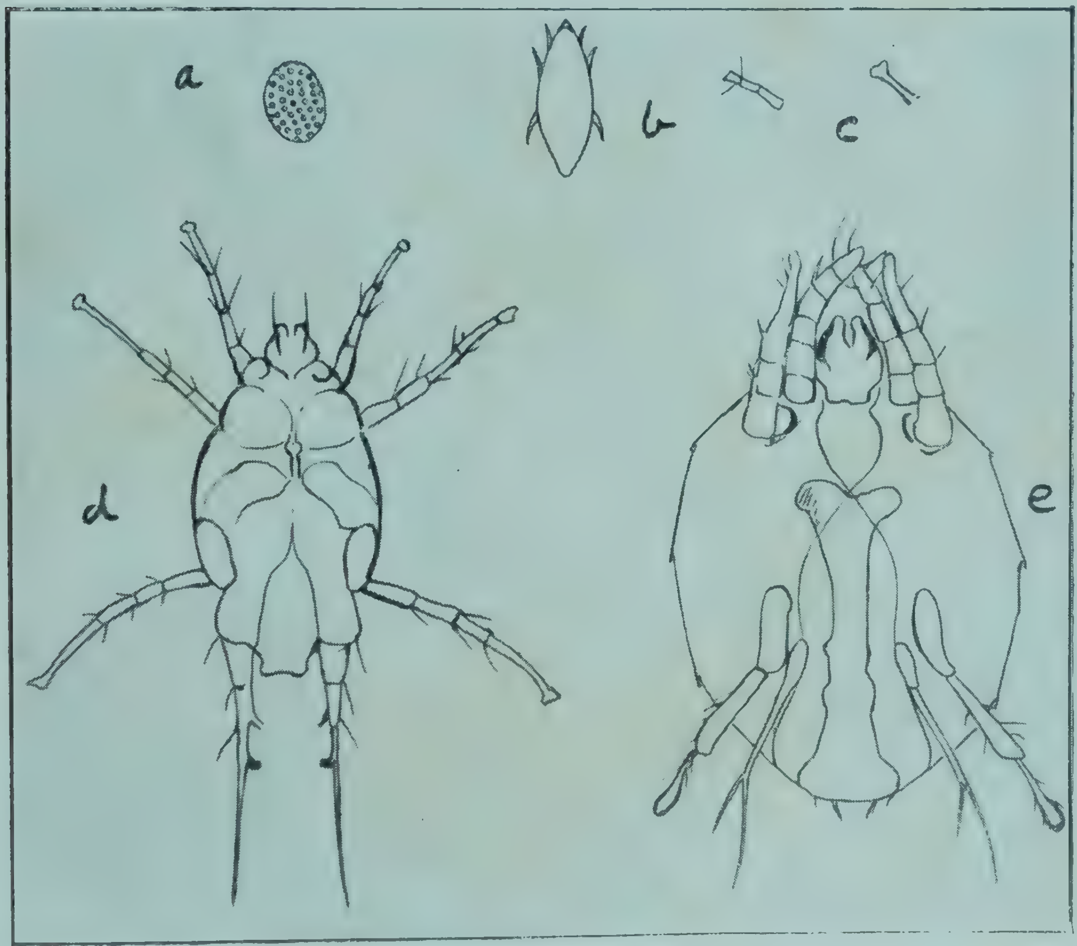

Fig. 2. The chilli mite in all its stages. a, egg; b, young one; c, tips of legs showing hooks and gland; d, male mite; e, female mite.

The cause of this disease, which had baffled our efforts so long, having been discovered, attempts were at once made to treat the diseased plants with the lime-sulphur wash. Spraying experiments were made at seven different centres in the Presidency—Gokak farm and Goshanhatti in the Belgaum District, Tikkoti and Muttagi in the Bijapur District, Baramati and Karkumb in the Poona District and at Rukdi in the Kolhapur State. Only one spraying was given. Favourable reports as to the efficiency of the treatment were received from all the above places. The results were most successful especially at Gokak and Rukdi, while in other places they were not so marked as the disease was in a far advanced stage at the time of treatment. These preliminary trials show that only one spraying is enough to control the disease if done at the time when the disease just appears. The cost of spraying per acre came to Rs. 10.

Search for other host plants of this mite has shown that besides *guar* (*Cyamopsis psoralioides*) as mentioned in the previous paper, it occurs on Zinnia, Dahlia, Tagetes, *Mirabilis jalapa*, Cape gooseberry, *Amaranthus polygonus* and *Physalis minima*. In the case of Zinnia, the affected plants get stunted in growth, the leaves are twisted and crumpled in various ways and no flowers are borne (Plate VI, fig. 2). If the flowers appear, they are few and are much reduced in size. Often the flowering parts are transformed into leafy shoots. Early in the season this year, a few affected Zinnia plants in front of the Agricultural College buildings, Poona, attracted the writer's attention, and examination of these showed on the under-surface of the leaves any number of moving mites agreeing with those on chilli. Cross-inoculation experiments were made, using the mite obtained from one host to inoculate the other. The results were quite successful, showing the typical symptoms of the disease in each plant. The Zinnia disease was one of the constant complaints received from the public, and the worst attack noticed in Poona during the last six years occurred this year (1920) in the Government House Gardens, Ganeshkhind, where all the Zinnia plants were completely spoiled. Its ravages were also reported from the Victoria Gardens, Bombay. No spraying trials were undertaken

as the season and the disease had far advanced when the reports were received.

As the mite has already been described in the previous paper,[1] it is not necessary to repeat the description here.

It is hazardous, no doubt, to attempt to identify the mite, as it is the work of a specialist. However, the following is the venture made by the writer.

In the Indian literature on mites a Litchi disease has been described by Misra.[2] The mite in the attacked parts of the plant causes a peculiar hairy growth and it is said to be a species of *Eriophyes*. There is another disease on cotton and jasminum. Here too in the attacked parts the mite produces woolly growth and it is said to belong to a species of *Phytoptus*. The chilli mite differs both in its morphological characters and in the effects produced on the host from these two species. Carpenter's[3] statement that the mite may belong to a red spider group (Tetranychidæ) does not seem to hold good. The Tetranychidæ[4] have six segments in their legs, while the legs of this mite have five segments (Plate VII, fig. 2). The mite comes very near to the yellow mite of the genus *Tarsonymus* described by Watt and Mann.[5] The description and illustrations of the yellow mite agree completely with those of this mite. The peculiar sucking discs with two hooklets at the end of the legs—characteristic of Tarsonymidæ[6]—are also noticed. It may therefore be a species of Tarsonymidæ.

[1] *Agri. Jour. India*, XV, pt. III

[2] *Agri. Jour. India*, VII, p. 286.

[3] A New Disease of the Irish Potatoes. *Phytopathology*, VIII, p. 286.

[4] Brown, Max. *Animal Parasites of Man*, 1906, p. 355.

[5] Watt and Mann. *Pests and Blights of Tea Plant*, 1903, p. 360.

[6] Brown, Max. *Animal Parasites of Man*, 1906, p. 356.

Selected Articles

ARTIFICIAL FARMYARD MANURE.*

BY

H. B. HUTCHINSON, PH.D.,

AND

E. H. RICHARDS, B.Sc., F.I.C.,

Rothamsted Experimental Station.

As a consequence of the campaign for increased food production during the war, and the resulting extension of the area under cereal crops, it was thought that, even after making allowances for disposal through the usual channels, there might still remain a surplus of straw which could not be utilized for feeding or for conversion into manure. It was, therefore, determined to investigate the possibility of converting straw into manure without the intervention of live stock, and a special grant-in-aid of the investigation was made to the Rothamsted Experimental Station by the late Food Production Department. Apart from war conditions, the possibility of adding to the supply of organic manure deserves consideration. In the case of market gardens particularly, the difficulty of obtaining adequate supplies of stable manure is increasing. The investigations described below indicate a method by which straw can be converted into a substance having many of the properties of stable manure. Further experiments to test the economic value of the process when conducted on a large scale are in progress at Rothamsted. Lord Elveden has also generously provided assistance and facilities for experimental work on his Pyrford estate.

* Reprinted from *Jour. Min. Agri.*, XXVIII, no. 5.

Of a considerable number of preliminary experiments to secure obvious breakdown and colour changes in fermenting straw, the most promising results were obtained when straw was subjected to the action of a culture of aerobic cellulose-decomposing organisms (*e.g.*, *Spirochœta cytophaga*). Further enquiry showed, however, that this effect was not due simply to the provision of an organism capable of breaking down cellulose, but rather to the indirect effect of the mineral substances contained in the culture fluid. From this point on, the question of food supply—as distinct from the addition of any particular species of organism—received special attention, and, as will be seen later, led to results possessing both theoretical and practical importance.

Without entering into a detailed account of the various stages of the investigation, we may state here that the most essential factors making for the production of well-rotted artificial farmyard manure are air supply, suitable temperature, and a suitable supply of soluble nitrogen compounds.

(1) *Air supply.* It has been found invariably that characteristic breakdown changes in straw remain suspended when a free supply of air is excluded either by intense consolidation or by immersion of the straw in liquid. The fermentation appears, therefore, to be an essentially aerobic one, at least in its early stages, and the typical disintegration of the straw with the production of dark-coloured plastic material does not take place in the absence of air. Moreover, the colour of the aerobically produced manure is rapidly reduced when oxygen is excluded. The great importance of air supply is shown by the following experiment, in which four lots of straw were fermented under aerobic and anaerobic conditions for three months at 37°C. (99°F.).

	Loss of dry matter	
	Straw without nitrogen	Straw with nitrogen
	Per cent.	Per cent.
Without air supply	16·3	17·1
With air supply	40·1	59·8

The data explain what may be seen in the ordinary heap of farmyard manure, *viz.*, that straw submerged in liquid urine, and therefore protected from air, remains in an unchanged state for long periods. On the other hand, the practice of carting manure from the yards and boxes and storing it in heaps in the field, although carried out for other reasons, provides better conditions for rotting than are likely to prevail where the dung is consolidated by trampling and saturated with urine.

(2) *Suitable temperature.* Except in those cases where straw is being fermented under otherwise unfavourable conditions, special measures to maintain a favourable temperature for fermentation are not called for. In common with other fresh fermentable materials, moist straw rapidly undergoes a preliminary fermentation during which the temperature may rise to upwards of 65°C. (149°F.). It is, however, in the subsequent stages that the effect of treatment becomes most evident in maintaining the temperature. Experience has shown that a supply of nitrogen, by increasing the energy of fermentation, leads to an increase of 15–20° C. (59–68° F.) in favour of straw which has received a sufficient supply of nitrogen, as compared with untreated straw.

(3) *A supply of soluble nitrogen compounds in suitable concentration, and possessing a neutral or slightly alkaline reaction.* Repeated experiments have shown that the most rapid breakdown of straw occurs when some source of nitrogen in an available or indirectly available form was supplied, and then only in those cases where the reaction of the solution was neutral or slightly alkaline. Hence the supply of nitrogen in the ammonium sulphate alone fails to lead to definite breakdown since the medium soon becomes markedly acid, while, on the other hand, the supply of an alkaline compound alone, such as caustic soda, is equally ineffective, since a source of nitrogen is lacking. The addition of nitrogen in the form of urine, urea, ammonium carbonate, or peptone within certain concentrations immediately sets in train rapid decomposition changes, and results within the period of a few weeks in the production of dark-coloured, well disintegrated, structureless material closely resembling well-rotted manure. That this should

be the case with urine was perhaps not remarkable, although the factors which operate in the essential dung-making process had not then been individually worked out, but that an essentially characteristic product could be obtained without the use of urine or of the fæcal portion of the manure as ordinarily produced was at once suggestive. On the basis of subsequent work, it may indeed be claimed that, in the production of normally well-rotted farmyard manure, the mass inoculation of the litter with the large bacterial population of the fæces does not exert any marked contributory influence on breakdown changes ; that the urine, as such, apart from being the carrier of nitrogen, does not induce any characteristic changes in the straw, while the typical smell and colour of stale urine from the manure heap may be successfully reproduced from straw treated with ammonium salts.

Although it is important that available nitrogen should be present for the rotting process, it is also not less essential that the quantity of nitrogen should not exceed a definite amount both actually as well as in concentration. In other words, if the concentration of ammonium carbonate produced from the decomposition of urine or urea exceeds a definite limit, not only are straw-breakdown changes definitely held up, but they continue to be inoperative until by volatilisation, and consequently loss of nitrogen to the air, the concentration or alkalinity has been reduced to the upper limit of growth of micro-organisms. *This must be regarded as particularly important, since the highest concentration for rapid breakdown is appreciably below that of the weakest undiluted urine.*

It follows that it is quite impossible to produce well-rotted dung by the use of neat urine without considerable losses. This fact may be illustrated by the following table, and, incidentally, is shown by all the investigations that have been carried out on the making of farmyard manure.[1] Three equal portions of straw were saturated either with water or urine and allowed to ferment for three months in the laboratory, the two portions with urine being subjected to different temperatures. As will be seen from the

[1] See, for example, Russell and Richards, *Jour. Agri. Sci.*, 1917, VIII, p. 495.

following table, these two portions fermented to different degrees —the dry matter losses being 49 and 60 per cent. respectively, *but the final nitrogen content was almost identical*, and practically three-fourths of the nitrogen supplied as urine was lost.

Temperature	Loss of dry matter	Nitrogen		
		Initial	Final	Loss—or Gain+
	Per cent.	mg.	mg.	mg.
Straw with water (36°C. = 97°F.)	40·1	71	97	+ 26
,, ,, urine (26°C. = 80°F.)	49·1	507	178	− 329
,, ,, ,, (36°C. = 97°F.)	59·8	507	176	− 331

It would be erroneous, however, to assume that such losses are inevitably connected with a satisfactory breakdown of straw, or that the conditions ordinarily obtaining in the farmyard at all represent optimum proportions between the straw which is to be decomposed, and the concentration of nitrogen in the urine which eventually serves for this decomposition. That equally good rotting may be obtained without loss of nitrogen is shown by the cases given in the table below. In the experiments to which the table refers, straw was incubated with urine in different concentrations for periods up to 86 days. Even after this period the losses that occurred with satisfactory rotting and within the lower concentrations were only about 4 per cent. of the total nitrogen of the final product. The ordinary losses of the manure heap are frequently more than tenfold this amount.

	Number of experiment				
	(1)	(2)	(3)	(4)	(5)
At beginning— Straw and urine nitrogen	77·5	157·6	237·6	317·6	397·6
After 86 *days*— Total nitrogen	77·3	153·1	226·8	262·1	308·0

In addition to *the two phases already mentioned*, (a) in which straw overloaded with nitrogen loses it to a definite degree, and (b) in which straw with the requisite amount of nitrogen may undergo rotting without appreciable loss and is therefore in a state of

equilibrium, there exists *a third phase* in which under-saturated straw, by the agency of micro-organisms, exhibits a well-marked property of picking up nitrogen, particularly in the form of ammonia, until the same final content of nitrogen in the rotted product is attained. Hence we might expect that in two different but adjacent portions of fermenting straw, the one overloaded with, and the other lacking, nitrogen, the former portion loses and the latter accumulates nitrogen until a common level is approached. That such is actually the case is illustrated by the following data, and is diagrammatically represented in Fig. 1. Ten portions of

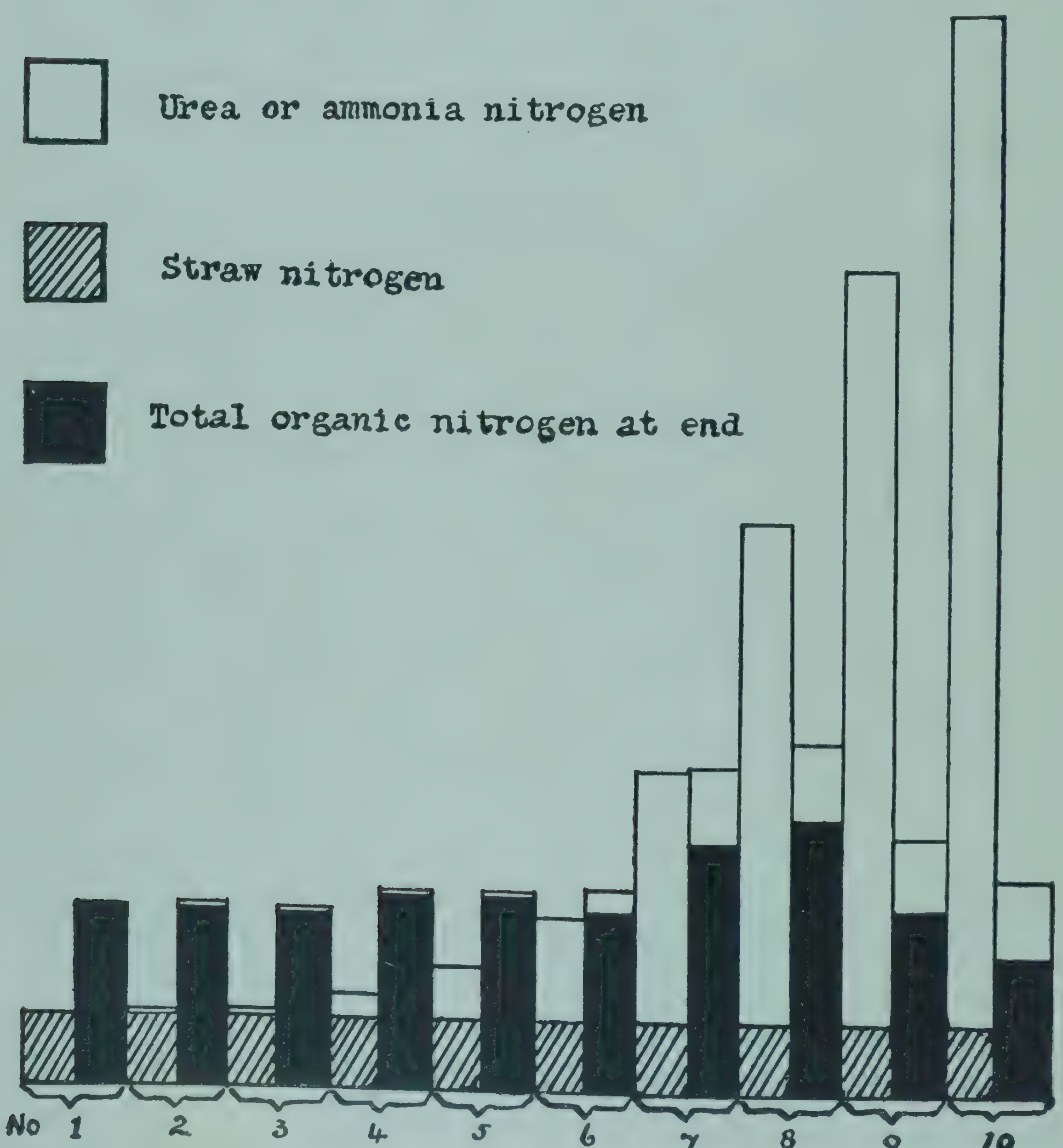

FIG. 1. The diil aagrlustrates the power of under-saturated straw to pick up ammonia lost by super-saturated straw. Ten portions of straw with increasing quantities of nitrogen (as urea) were allowed to ferment for three months.

straw were moistened to the same extent, and while one received water only, the others received additions of soluble nitrogen in the form of urea in varying quantities, until the last portion was saturated with a solution similar in concentration of nitrogen to that of horse urine (1 per cent. of nitrogen). The different portions were then kept in an incubator for 3 months, at the end of which time it was evident that, contrary to expectation, the straw, without or merely with low doses of nitrogen, had passed through a marked rotting process. On analysis, however, it was found that there had been a definite accumulation of nitrogen in the lower members of the series, while the higher members had lost in some cases the greater portion of their original nitrogen.

The decomposition of straw in the presence of varying quantities of nitrogen as urea.

	Number of experiment									
Treatment ..	1	2	3	4	5	6	7	8	9	10
At beginning										
Straw nitrogen mg.	71	71	71	71	71	71	71	71	71	71
Urea nitrogen ,,	—	5	10	24	48	97	243	486	729	973
Total nitrogen ,,	71	76	81	95	119	168	314	557	800	1,044
At the end of 3 months										
Organic nitrogen mg.	180	177	174	190	192	171	245	269	181	134
Ammonia ,, ,,	—	5	2	4	4	29	74	68	71	76
Total ,, ,,	180	182	176	194	196	200	319	337	252	210
Gain or loss ,,	109	106	95	99	77	32	5	—220	—548	—834
Dry matter, loss per cent. .	49	46	45	49	47	53	51	48	19	14

In seven out of the ten cases the final nitrogen of the fermented straw varied only between 180 and 210 mg., irrespective of the nitrogen content of the original mixture. It should also be noted that the extent of the rotting, *i.e.*, the loss of dry matter, in experiments 1–8 was very much greater than in 9 and 10 in which the straw was subjected to the action of solutions closely approaching

the concentration of ordinary urine, the high alkalinity of the latter exercising a check on decomposition.

In the main, the nitrogen retained by super-saturated straw, or such as is accumulated by under-saturated straw, as in Nos. 1–6 in the above table, appears to be stored up in an organic or non-ammoniacal form. The maximum retention has been found to occur within the first four weeks, after which time breakdown of this organic nitrogen to ammonia and consequent loss by volatilisation seems to keep pace with loss of dry matter. Finally, the material assumes a "stabilised" condition—the loss of nitrogen becomes greatly diminished or may be absent altogether for long periods. These three phases—accumulative, dispersive and stable—are shown in Fig. 2, which illustrates the type and extent of the

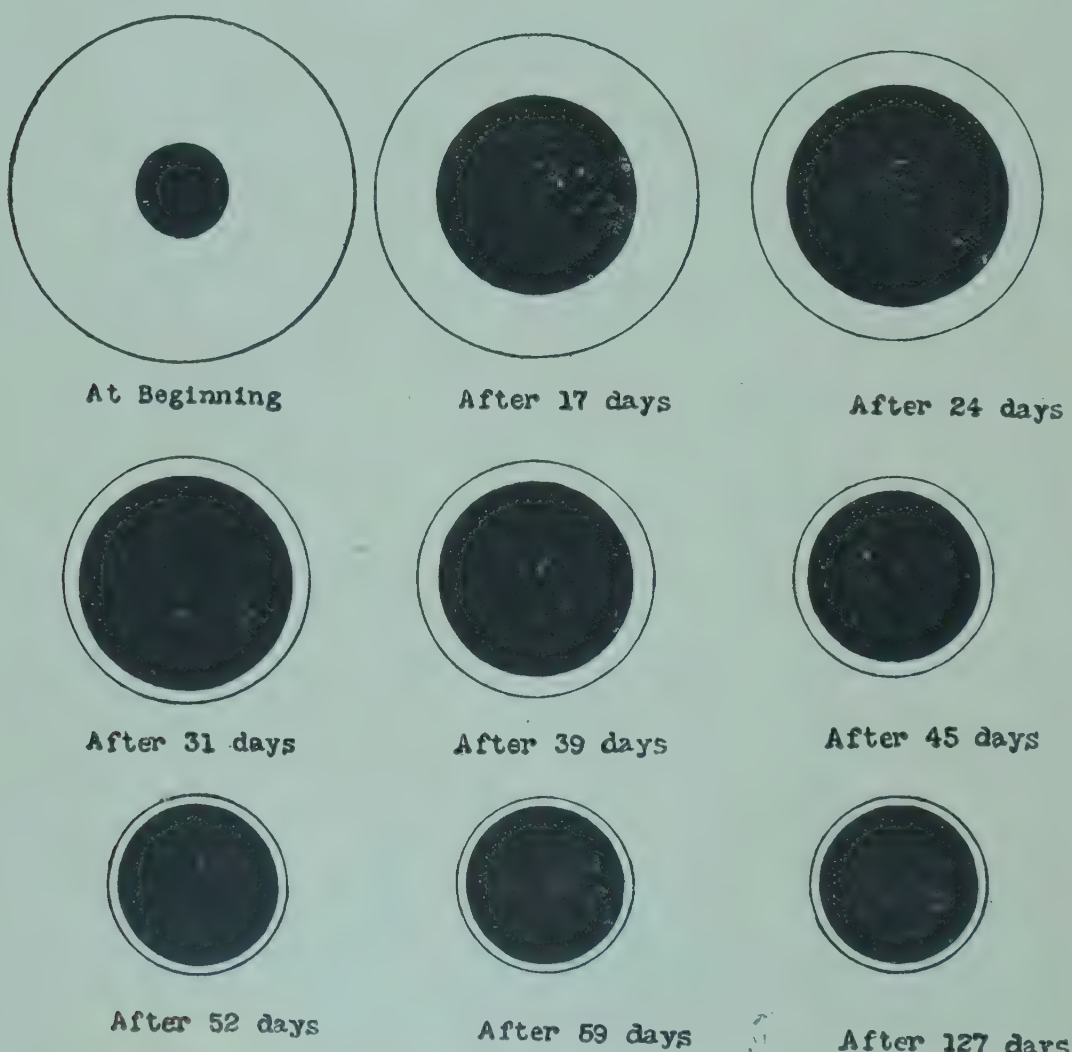

FIG. 2. The diagram illustrates the changes that occur when straw is fermented in the presence of urine. The black discs represent fixed nitrogen, and the white outer circles represent ammonia nitrogen.

changes taking place in a mixture of straw and urine during a period of four months. Between the 60th and the 120th day little change is found to take place either in the amount of "stabilised" or "fixed" nitrogen or the proportion of this nitrogen and the ammonia which appears to be held by fermented material even at a high temperature (37°C. = 99°F.), and in spite of the frequent handling and exposure associated with sampling operations. In general, it may be stated that when straw has worked from an unsaturated to a "stable" phase little or no free ammonia is to be found, but straw which commences with a super-abundance of nitrogen appears to hold, when in a fermented state, upwards of 14 per cent. of its nitrogen in the form of ammonia so long as the material is in a moist condition. Desiccation leads almost to complete loss of ammonia, and in this respect as well as in the proportion of ammonia in the moist material, the artificial resembles the natural manure.

From the study of the inter-relations between nitrogen and straw, we have come to the conclusion that the amount of nitrogen necessary for pronounced rotting, and the amount which straw is capable of "fixing" in the form of ammonia are identical, and that, in general, the figure varies only between 0·70 and 0·75 parts of nitrogen per 100 parts of dry straw. Within these limits fermentation proceeds without loss of nitrogen, and it is obvious that, except in so far as the nitrogen content of the original straw varies, the final "stabilised" product obtained when rotting has proceeded to the extent of 40 to 45 per cent. of dry matter must likewise exhibit comparatively slight variation in its nitrogen content. In our experiments the "stabilised" product obtained from the fermentation of straw under a variety of conditions possesses a nitrogen content of about 2 per cent. calculated on the dry material.

It thus becomes possible to estimate fairly accurately what the nitrogen content of any particular sample of fermented straw will be when rotting has proceeded to an appreciable extent. If, for example, the nitrogen content of the original straw is equal to 0·50 per cent. and we assume that the theoretical amount of ammonia nitrogen, equal to 0·72 lb. of nitrogen for 100 lb. of straw, has been fixed, then, with a loss of 40 per cent. of

dry matter during fermentation, the resultant rotted straw will contain $(0 \cdot 50 + 0 \cdot 72) \times 100 \div 60 = 2 \cdot 03$ per cent. of organic nitrogen in the dry matter. An additional amount of ammonia nitrogen would probably result in a portion remaining as free ammonia which, as indicated above, would be liable to loss if the fermented straw were allowed to become dry. The data thus obtained enable us to turn to the process of inducing the fermentation of straw on a large scale, and are also capable of application to the conditions operating in the production of ordinary farmyard manure.

Suggested method for the preparation of artificial manure.*

As regards large scale work, a number of factors have to be taken into account which did not operate in the laboratory experiments. Experience has shown that urea and ammonium carbonate are the most suitable carriers of nitrogen since they ensure a favourable alkaline reaction, and lead to rapid breakdown, provided that they are not present in large excess. They are, however, far too expensive at the present time to admit of general use in farm work, although a reduction in the cost of manufacturing synthetic urea would create conditions favourable to its extended use. As an alternative source of nitrogen, cyanamide (nitrolim) and sulphate of ammonia have been used with success. Whilst cyanamide already contains sufficient free lime to keep in check any acid compounds formed during fermentation, sulphate of ammonia must be supplemented by the addition of a base, and for this purpose finely-ground chalk, ground limestone, or waste lime from causticising plant at soap works may be used. For general purposes it will be found that upwards of ¾ cwt. of sulphate of ammonia and 1 cwt. of finely divided carbonate of lime per ton of straw are sufficient to induce fermentation. The main obstacles to large scale operations at the present time arise from the great tardiness

* This process, as well as its application to the purification of sewage, has been covered by Letters Patent (British Pat. No. 152387).

with which raw straw takes up the moisture necessary for fermentation. Where pits are available this difficulty may be overcome by allowing the straw to remain immersed for 2 to 4 days, after which the free liquid may be drained off. In the case of heaps or stacks on open ground no advantage appears to be obtained by continued wetting with large quantities of water, and we suggest, as a more effective method of securing the necessary saturation of the straw, sprinkling the heap comparatively lightly with water and allowing a couple of days to elapse before a second sprinkling is given. During this time a slight fermentation with increase in temperature sets in. rendering the straw more capable of absorbing a second slight application of water than would otherwise be the case. When examination has shown that the interior of the heap has become uniformly moist, the source of nitrogen may be applied in the form of solution, or in the case of cyanamide and other products, this may be broadcasted over the surface of the heap and watered in. The most convenient method of making the heap, wetting the straw, and supplying the necessary nitrogen for fermentation depends so much on local conditions that much must be left to the initiative of the farmer himself.

General characteristics of artificial farmyard manure.

Artificial farmyard manure prepared from straw is a well disintegrated plastic material in which the tubular character of the straw has been to a great extent destroyed. There is an almost complete absence of smell, the little there is being slightly fusty or mouldy in character. When prepared through the agency of a compound in the presence of free lime, there is a tendency towards the production of a blackish colour, while if prepared from soluble alkalies such as ammonium carbonate, liquid ammonia or compounds giving free ammonia such as urea or peptone, or in the presence of sodium hydroxide or sodium carbonate, the colour is dark brown, and differs only slightly from the natural product. The liquid, which is gradually expressed from the fermenting straw as more and more dry matter is lost by fermentation, has a

dark brown colour and a smell which is indistinguishable from stale urine.

Application of results to the production of ordinary farmyard manure.

Since it has been possible to produce material identical in physical properties with well-rotted farmyard manure, differing only in chemical composition in so far as the latter contains appreciable quantities of phosphorus and potash derived from foods consumed by the animal, the possibility suggested itself that the results might be applicable to the making of ordinary farmyard manure and led to an inquiry in this direction.

Of the three constituents ordinarily present in manure—urine, fæces and straw—the fæces appears to contribute to the physical character of the product only, since manure can be produced without their presence. Moreover, definite experiments have shown that, chemically, fæcal nitrogen is to a great extent inert and is not capable of contributing to the decomposition of straw to any degree comparable with urine nitrogen. On the contrary, certain methods of feeding farm animals, and particularly of horses, sometimes lead to the production of fæces containing quantities of readily available carbohydrates, and it has been shown[1] that such fæces are capable of supporting the fixation of atmospheric nitrogen. There is every reason to suppose, therefore, that the fæcal portion of the manure heap inclines slightly in the direction of itself requiring nitrogen rather than acting as a source of nitrogen for the decomposition of straw. With the above exception of some horse fæces, the solid excrements of farm animals may be regarded as having reached a state similar to that observed above in fermented straw, *i.e.*, containing roughly 2 per cent. of nitrogen in the dry matter. This is borne out by the following mean figures which have been obtained from various sources :—

Horse fæces	(mean of 8 records)	=	2·00	per cent. N in dry matter.
Cow	„ („ „ 11 „)	=	1·88	„ „ „ „
Sheep	„ („ „ 7 „)	=	1·92	„ „ „ „
	Average of 26 records	=	1·93	„ „ „ „

[1] *Jour. Agri. Sci.*, 1917, VIII, p. 299.

We thus see that during the process of digestion, and also possibly by virtue of bacterial action in the intestinal tracts, the percentage of organized nitrogen closely agrees with the figure repeatedly found for fermented straw to which purely mineral nitrogen was supplied, and subsequently converted by a bacterial action into organized nitrogen.

Since evidence of this stabilised condition is found in the product of the fermentation of straw and urine, and also in the undigested portion of food passing through the animal, it might be expected that comparable conditions would prevail in the manure heap. Despite the fact that the manure heap usually consists of the liquid and solid excrements of different animals fed with widely different diets, together with litter of various kinds and in variable proportions, and that this mixture is allowed to mature under conditions absolutely lacking in uniformity, the majority of the available data regarding the composition of farmyard manure indicate a striking similarity in the percentage of fixed or "non-ammoniacal" nitrogen. Without giving details of the methods of feeding or the conditions under which the manure was produced, it may be sufficient to state that the mean content of fixed or organized nitrogen in manure made under controlled conditions in America, on the Continent, and in this country, proves to be 2·09 per cent. as a mean of 43 records. We are now in a position to appreciate more accurately the character of the changes which proceed during the making and storage of manure. Repeated experiments carried out during the last three decades have shown that during this process a very considerable proportion of the nitrogen originally contained in the food and litter is almost invariably lost, and this loss, which may amount to upwards of 40 or 50 per cent. of the whole, appears to fall largely, or even exclusively, on the urine nitrogen, *i.e.*, the most valuable nitrogen, since it is the most readily available constituent of the manure. To prevent or reduce this loss both chemical and physical measures have been suggested, all of which have proved either ineffective or have interfered seriously with the rotting process.

If dung-making be regarded as essentially a straw-rotting process it is possible to obtain some explanation of much of the loss which has been found to occur. We have seen that the nitrogen-fixing power of straw is strictly limited, and that any surplus nitrogen in the form of ammonia is liable to loss by evaporation. It may therefore be assumed that the practice of supplying concentrated feeding stuffs to farm livestock merely results in an increased production of soluble nitrogen, which, owing to the normally overloaded condition of the litter, is liable to relatively greater loss than where such feeding stuffs are not used.

We have attempted to test the accuracy of this view by computing the amount of nitrogen that ought under ordinary conditions to be recovered in the form of manure from any given system of feeding. For this purpose we have taken—

(*a*) the total amount of nitrogen contained in the straw used as litter ; this is apparently not in a form liable to loss ;

(*b*) the amount of indigestible or fæcal nitrogen as calculated from the digestion co-efficients of the foods consumed ;

(*c*) the amount of nitrogen which the quantity of litter employed should be theoretically capable of retaining, *i.e.*, 0·72 lb. of nitrogen per 100 lb. straw ; and

(*d*) the amount of nitrogen present as ammonia at the end of the experiment ; this quantity is extremely variable and is determined by the actual conditions, aeration, exposure, and the length of the period during which the manure is stored.

The application of this method to the actual results obtained in a number of feeding experiments shows that a fairly close approximation may be obtained.

Two instances may be given, the first relating to Professor T. B. Wood's experiment at Cambridge[1], and the second to that of

[1] *Jour. Agri. Sci.*, 1907-08, II, p. 207.

Professor Hendrick[1] on the feeding of bullocks on roots and straw. The following table gives an extract of Professor Wood's data relating to the amount of total and digestible nitrogen supplied to the respective sets of animals, and the net amount excreted after deduction of the calculated nitrogen due to the live-weight increase of the animals. As the animals were not fed with straw but were able to pick over that supplied as litter, it has been assumed that one-quarter of the whole would be consumed, and due allowance has been made for this. In the two instances, therefore, after making this deduction, 41·15 and 83·85 lb. of nitrogen were supplied to the animals, whilst only 30·9 and 46·70 lb. were recovered in the manure. The totals obtained by calculating the indigestible or fæcal nitrogen, together with that contained in the litter and the amount which this litter is theoretically capable of fixing, closely approach those obtained by actual analysis of the manure, being 33·6 as against 30·9 lb. and 46·51 as compared with 46·70 lb. in the two cases respectively.

	No cake		Cake	
	Total nitrogen	Indigest. or fæcal nitrogen	Total nitrogen	Indigest. or fæcal nitrogen
	lb.	lb.	lb.	lb.
Mangolds	17·6	4·0	17·6	4·0
Hay	21·3	8·5	21·3	8·5
Straw	9·0	1·7	8·6	1·65 (¼ taken as food)
Cake	—	—	42·8	5·56
Total nitrogen minus nitrogen in live-weight increase ..	41·15	14·2	83·85	19·71
			Calculated	
Fæcal nitrogen	—	14·2	—	19·71
Straw ,, ...	—	7·3	—	7·0
Nitrogen fixed by litter	—	10·2	—	9·8
Nitrogen found as ammonia ..	—	1·9	—	10·0
Total (Calculated)		=33·6		=46·51
Total actually found		=30·9		=46·70

[1] *North Scot. Coll. Agri. Bull.* 22, 1918.

The data referring to Professor Hendrick's experiments are contained in the table below in a somewhat condensed form. The total amount of nitrogen supplied to the animals as food amounted to 613 lb., and of this it has been calculated that 42 lb. were retained by the increase in live-weight of the animals, thus making the total amount which should have been present in the dung equal to 671 lb., whilst only 524 lb. were actually recovered as organic and ammonia nitrogen. For the calculation, we have taken the fæcal nitrogen as given by Professor Hendrick as 276 lb., the nitrogen contained in the litter as 100 lb., and the amount of nitrogen which would be fixed by the litter (equal to 146 cwt. with a dry matter content of 91 per cent.) as 107 lb. It will be seen that the sum thus obtained is 537 lb. by calculation, as against 524 lb. by analysis. It should be noted, however, that Professor Hendrick himself calls attention to the fact that the cattle used in the experiment did better than might have been expected from accepted scientific standards of digested litter, and raises the question as to whether the foods actually used were not more digestible and of higher starch value than is allowed in Kellner's tables. If this were the case, it would simply mean that the amount allowed in our calculation as indigestible or fæcal nitrogen is somewhat too high, and would consequently bring the totals of the analytical and the calculated amounts into still closer agreement.

Analytical data	lb.	*Calculated data*	lb.
Nitrogen supplied in food	=613	Indigest. (fæcal) nitrogen	=276
,, ,, ,, litter	=100	Nitrogen in litter	=100
Total nitrogen	=713	Nitrogen fixed by litter (16,352 lb. @ 91 per cent. dry matter × 0·72, *i.e.*, fixation constant)	=107
Total nitrogen recovered in dung	=524	Nitrogen as ammonia	=54
		Total calculated ..	=537

Similar calculations have been made in the case of other feeding experiments, but these two instances will probably suffice to show

that the amount of nitrogen which we found straw to be capable of fixing in the laboratory, is also most probably built up into organic form and to the same extent under ordinary farm conditions. It is, perhaps, outside the scope of this paper to suggest means by which the observed losses which occur in the making of manure may be minimised, but rational practice would appear to lie in the direction of a more liberal use of litter in order to increase the amount of ammonia that can be fixed, with the further result of a considerable increase in the dung-making capacity of a given number of stock.

SCIENCE AND CROP PRODUCTION.*

BY

E. J. RUSSELL, D.Sc., F.R.S.,

Director of the Rothamsted Experimental Station.

THE beginning of much of our scientific work on crop production goes back to the year 1843, when Lawes and Gilbert set out to discover why farmyard manure is such an excellent fertilizer. Two opposing explanations were offered by the chemists of the day; the older view, coming down from the eighteenth century, was that the fertilizing value lay in the organic matter; the newer view put forward by Liebig in 1840 was that it lay in the ash constituents —the potash, phosphates, etc.,—left after the manure is burnt. Lawes and Gilbert considered that it lay in the ash constituents *plus* the nitrogen of the organic matter, and they devised a critical field experiment to decide the matter. They divided a field of wheat into plots of equal size, of which one received farmyard manure at the rate of 14 tons per acre, another received the ashes of exactly the same dressing of farmyard manure, a third received the mineral matter of the ashes *plus* some of the combined nitrogen that had been dissipated on burning, and a fourth lay unmanured. The results were very striking :—

Broadbalk wheat field, 1843.

	Grain Tons per acre	Straw Cwt. per acre
Farmyard manure	22	13
No manure	16	10
Ashes of farmyard manure	16	10
Mineral matter of ash *plus* sulphate of ammonia to supply combined nitrogen	26¼	15¾

* Abstract of a farmers' lecture of the British Association delivered at Edinburgh on September 7, 1921. Reprinted from *Nature*, dated 22nd September, 1921.

The ashes proved ineffective, but the ashes *plus* the combined nitrogen acted just as well as farmyard manure ; it is therefore these that constitute the fertilizing constituents of the manure. Thus the old controversy was decided in a way not uncommon in science ; neither side proved to be entirely correct, but both sides were found to have some basis of truth. Lawes and Gilbert did not rest content with this purely judicial and scientific conclusion ; they saw that they could make up this effective mixture of ashes and combined nitrogen from mineral substances without using farmyard manure. Even in their day farmers were unable to obtain sufficient farmyard manure, and it was therefore a great achievement to be able to supplement the limited supplies by this mixture. A factory was set up, and the manufacture of the so-called artificial fertilizers began. Subsequent experience showed that the ash constituents are not all equally necessary ; in practice only two of them, potash and phosphates, need be supplied in addition to nitrogen.

Chemists are rightly proud of artificial fertilizers, for they have proved extraordinarily successful in augmenting crop production all over the world. The demand for them is enormous, and in consequence prices have risen considerably within the last thirty years. Agricultural chemists are always looking out for new substances, and even during the war a new fertilizer, ammonium chloride, was added to the list and new plant has been erected for its manufacture. Modern manufacturing facilities are, perhaps, adequate for present demands, but it is certain that much more fertilizer could be used, and that as farming improves the demand will increase.

Progressive farmers have long passed the stage when it was necessary to demonstrate that artificial manures increase crop production ; the position now is the much more difficult one of deciding how much money it is wise to spend on fertilizers. The old view was that the crop yield was proportional to the manurial dressing, *i.e.*, that the more the manure the bigger the crop. Lawes and Gilbert showed this was not altogether correct, and that the yield fell off after a certain sized dressing was reached ; this

relationship is expressed by a straight line which ultimately becomes a curve. A later view set up by Mitscherlich was that the effect of the manure is proportional to the decrement from the maximum obtainable; that therefore the first dose of manure has a large effect; but the further doses have progressively less action. This relationship is expressed by a logarithmic curve. The present view is that the effect is at first small; then it increases and then decreases; this relationship is expressible by a curve resembling that for autocatalysis. The important practical consequence is that moderate dressings are more profitable than small ones, but they are also more profitable than much larger ones (Fig. 1).

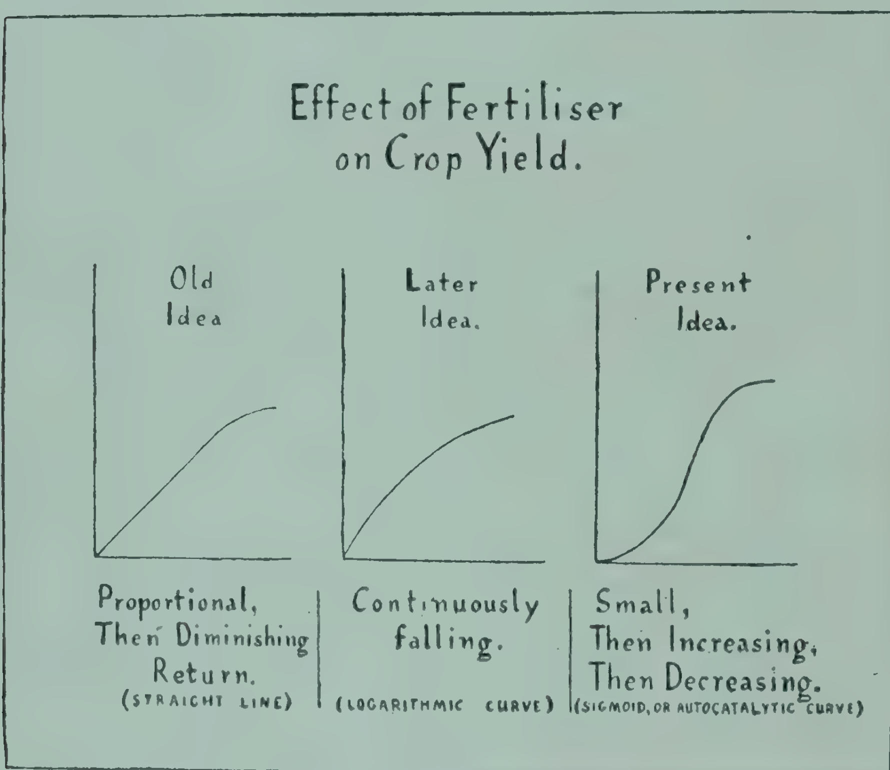

FIG. 1 Curves showing relationship between crop yield (plotted on vertical axis) and quantity of fertilizer used (plotted on horizontal axis).

There is no difficulty about the general rule; the difficulty arises when one tries to define a moderate dressing. The problem is further complicated by the fact that the effect of the dressing is

greatly influenced by the time when it is put on to the land. In our own case the results have been as follows :—

Date of application of manure	Increased yield of grain Bushels per acre			Increased yield of straw Cwt. per acre		
	Feb. 10,	March 6,	May 10	Feb. 10,	Mar. 6,	May 10
Single dressing	nil	0·9	2·7	2·7	6·9	9·4
Double dressing	7·0	—	3·7	11·7	—	12·7

This experiment ought to be repeated in many districts, for it is by no means certain that farmers generally are using the most profitable quantities of fertilizer at the most effective time. It is, however, necessary to take into account something more than the quantity and the time of application of the fertilizer. It is essential also to have a suitable mixture. In the old days this question was thought to be fairly simple. Chemists used to think that if they knew the composition of the ash of plants they would know what manure to use ; it should supply all the ash constituents in the quantities present in the plant. This is now known to be wrong ; the composition of the ash affords no guidance to manurial requirements, as was, indeed, shown by Lawes and Gilbert in 1847. The distinguished French chemist, Georges Ville, emphasized the fact that only properly conducted field trials would ever settle the question. Vast numbers of such experiments have been made, and they show that the problem is more complex than Ville thought. It is now known that no single formula expresses the fertilizer needs of a crop ; every district, almost every farm, has its own special requirements.

Still further difficulty is introduced by the fact that the various artificial fertilizers not only increase crop yields, but also influence the composition and habit of growth of the crop. Nitrogenous manures tend to a vegetative growth of large, deep-green leaves which are somewhat liable to be attacked by fungoid pests. Phosphates improve root development, and are therefore of special value for swedes and turnips ; they also hasten ripening of grain,

and are therefore particularly useful in late districts ; they increase the feeding value of crops, and are therefore useful for fodder crops ; and they have a remarkable effect on the development of clover, which is not yet fully understood, but which has revolutionized the treatment of pastures in this country. Potassic fertilizers improve the vigour of the plant and increase its power to resist fungus attacks. These and other special properties of fertilizers are now well established, and advantage is taken of them in drawing up fertilizer schemes to suit the special requirements of each farm.

It has already been pointed out that this work on artificial fertilizers arose out of Lawes and Gilbert's discovery that the wheat crop of 1843 grew just as well when supplied with the ash constituents *plus* combined nitrogen as when supplied with farmyard manure. They repeated the experiment year after year ; periodically the results were collected and even after fifty years on an average the artificials had done as well as the farmyard manure. In consequence of this and other experiments many agricultural chemists developed the view that artificial manures were at least as good as farmyard manure for ordinary use on the farm ; but wider knowledge has shown that this is not the case ; it is only a first approximation to say that artificial fertilizers are equally as good as farmyard manure ; we now know that farmyard manure produces effects of the highest importance to the land which no known combination of artificial fertilizers will bring about.

Examination of the Broadbalk data in the statistical laboratory recently instituted at Rothamsted under Mr. R. A. Fisher shows that farmyard manure differs in two ways from artificials—the variation in yield from year to year is diminished by the use of farmyard manure, as is also the deterioration in fertility due to continuous cropping for eighty years. No fewer than fifteen different combinations of fertilizers are tested against farmyard manure, and while some of them come out quite well on an average of twenty-five or fifty years, they fluctuate considerably from season to season, and they show manifest signs of deterioration as the years pass by. Many farmers prefer a steady yield to a fluctuating one, and this, of course, is sound, cautious business. Farmyard

manure never does badly even in the worst seasons, but, on the other hand, it does not give record crops even in the best seasons. What we should like would be something possessing the special values of farmyard manure in bad seasons, and of artificials in good ones.

Further, there is a deterioration of yield on all our plots treated with artificials excepting perhaps those receiving exceptionally high dressings. This is shown on both the wheat and the barley plots and it is greatest on those plots where one of the essential fertilizer constituents is withheld (Fig. 2).

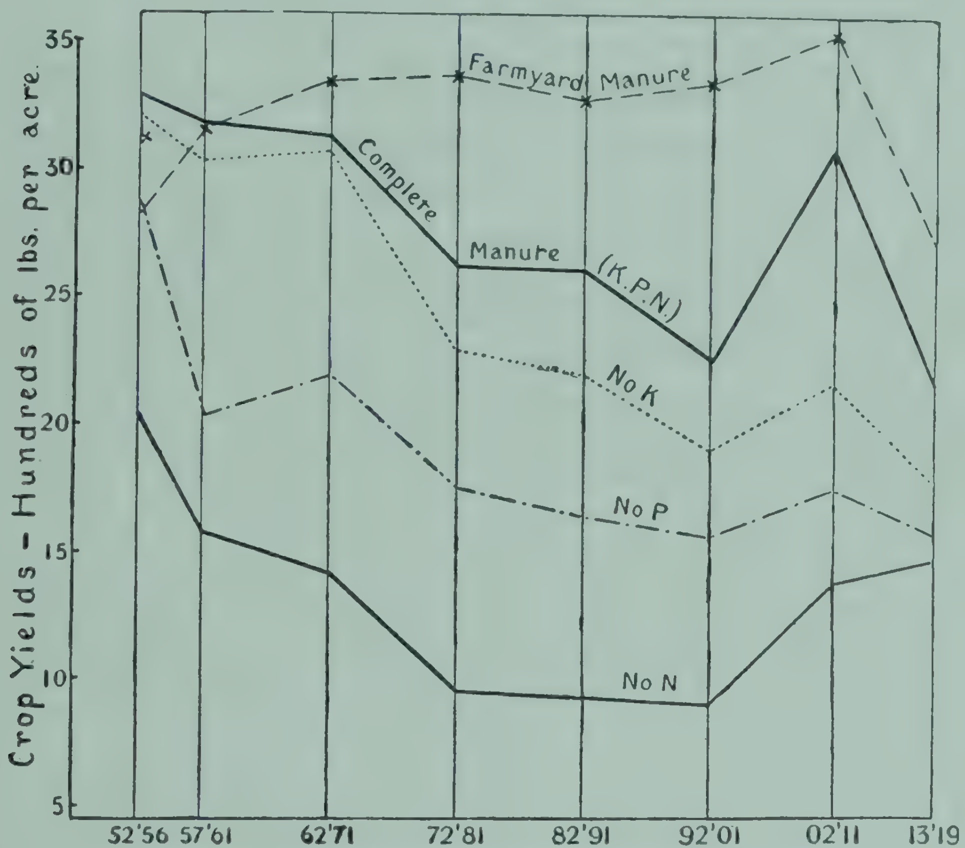

FIG. 2. Effect of fertilizers on yield of barley.
(Horsfield, Rothamsted, 1852–1919.)

There is a third effect, which is very marked in rotations. Farmyard manure appears to have a greater effect than artificials in increasing the growth of clover. Unfortunately the number of experiments is not very great, but, so far as they go, they show a striking superiority over artificials, and this extends not only to the clover, but also to the succeeding wheat crop.

The results at Rothamsted are :—

Manure applied to previous corn crop	Yield of clover hay Cwt. per acre	Yield of succeeding wheat crop	
		Grain Bushels per acre	Straw Cwt. per acre
Farmyard manure	62	45	45·3
Artificials only	46	37	36·8

At present we cannot explain all these remarkable facts. There are several possibilities :—

(1) Farmyard manure is known to exercise remarkable physical effects on the soil, causing it to become puffed up so that the empty pore spaces increase in size. The air supply to the roots thus becomes better, the water supply is more evenly regulated, the work of the tillage implements is lightened, and a good tilth is more easily obtained. The difference is well shown by the root crops—swedes, turnips, and particularly mangolds, which are very sensitive to soil conditions, and being sown late, are liable to suffer from spring and summer droughts. The plots at Rothamsted receiving farmyard manure contain always some 2—5 per cent. more moisture than those receiving no manure or artificials only, and this enables the mangolds to keep growing during a drought which effectually checks all plants not receiving farmyard manure.

(2) It is possible that there are chemical constituents in farmyard manure which are not present in our artificial fertilizers. The old idea that nitrates, potash, and phosphates only are necessary may be wrong. Recent work by Maze in Paris and by Dr. Winifred Brenchley at Rothamsted show that some of the other elements may also be helpful. In the Rothamsted experiments very small quantities of boric acid added to the soil caused distinct increases in crops fully fertilized with artificial manures. We cannot as yet recommend farmers to adopt this kind of manuring with special substances, because it is very easy to overstep limits and do much damage to the crop, for the plant suffers seriously from even slight

excess. With fuller knowledge, however, it may prove possible to keep this special manuring within bounds.

(3) In the case of the clover crop the farmyard manure or the straw in the litter may have a special effect on the organisms living in the root, causing them to increase the amount of nitrogen fixation and thus give larger clover crops and further enrich the soil in nitrogenous organic matter.

Work on these problems is progressing; the scientific investigator has, of course, to find out exactly what is happening before he can show the practical man how to exercise control.

But in the meantime it is necessary for us to be practical and to do something, and the most obvious line of action is to increase the amount of farmyard manure or similar substances on the farm. We can proceed in two ways; first, wastage can be cut down. We estimate that the farmers of the United Kingdom make about forty million tons of farmyard manure a year, and waste about ten million tons. We have shown that the best results are obtained when manure is made under cover and the amount of litter properly adjusted to the amount of nitrogen in the animal excretions. Correct adjustment is a counsel of perfection, but a great improvement is possible over the present haphazard methods. In practice nitrogen is always lost through exposure to weather, greatly to the detriment of the manure. The provision of some shelter for the heap is not difficult, and, as Prof. Berry has shown at Glasgow, it is distinctly advantageous.

Another method is to increase greatly the amount of farmyard manure or similar substances produced on the farm. This could be done by running on more animals. The number of livestock per acre could be much increased by the general adoption of the methods of some of the Scottish and Danish farmers, who keep their animals largely on the produce of their arable land. The problem is closely bound up with financial considerations, but the experiments of Mr. J. C. Brown at the Harper Adams Agricultural College show that more profit is obtainable from the soiling system than from the older methods of the south.

At Rothamsted we are examining possible substitutes for farmyard manure, green-manuring, and the aetivated sludge method of producing manure from sewage, both of which seem quite promising. We tried using straw as manure, but without success ; so soon, however, as the straw was rotted, much more promising results were obtained. The conditions for the proper rotting of straw, investigated at Rothamsted by Dr. H. B. Hutchinson and Mr. E. H. Richards, were found to be proper air and moisture supply, suitable temperature, freedom from acidity and the proper proportion of soluble nitrogen compounds. All these conditions are easily obtainable on the farm, and it is now possible to make an artificial farmyard manure from straw without the intervention of animals. So far the results seem quite satisfactory. Arrangements are being made for demonstrations on an extensive scale during the present season.

All these problems I have been discussing represent work of interest to the present generation of farmers ; but the scientific investigator cannot be restricted to problems of present day interest. Some of the best work of to-day may never reach the farmer in our time, and, indeed, unless it is developed, it will never reach the farm at all. We now know that the farmyard manure and the green manure put into the soil are not really agents of fertility, but only raw materials out of which fertility is manufactured. The work is done by myriads of living creatures in the soil, which are too small to be seen by the naked eye, and only incompletely revealed even by powerful microscopes. Some of them are useful to the farmer and some not, many of them taking their toll of the valuable plant food in the soil. Their activity fluctuates daily, almost hourly, and their numbers are counted, and their work is watched in our laboratories. Much of their activity is helpful to the farmer ; it makes nitrates, indispensable for the growth of plants. Much of their time, however, is spent in undoing the good work they have done, and results in the destruction of a large proportion of the nitrates made. We are studying this population, and with fuller knowledge we hope to control it and make it serve the farmer

just as horses, sheep, and cattle do; but we are a long way from that yet.

Finally an attack is being made on a much more difficult problem. The growth of a crop is like the movement of a motor car; it cannot go on without a continuous supply of energy. In the case of the car the energy comes from the petrol; in the case of the growing crop it comes from sunlight. The plant as we grow it, however, is not a very efficient transformer; a crop of wheat utilizes only about half of 1 per cent. of the energy that reaches it. During the last eighty years the growth of crops has been improved, thus increasing their efficiency as utilizers of energy; but we are still a very long way from the 30 per cent. efficiency which the motor engineer has attained. Better developments of our present methods will no doubt carry us further than we have yet gone, but some wholly fresh ideas are necessary before we can hope to bridge the enormous gap that now exists between the actual and what is theoretically possible. There seem to be at least six ways in which we might improve crop production :—

(1) We can hope for further improvements by the use of new varieties capable of making better growth than those ordinarily cultivated. Plant breeders all over the world are attacking this problem with much success, and many of the new sorts show considerable promise.

(2) Much can be done by control of plant diseases. Unfortunately we have no means of knowing how much is lost each year by pests or disease, but it is undoubtedly considerable. Laboratories for studying plant pathology have been set up at Rothamsted and elsewhere, and we are hoping to achieve good results; much valuable information has already been obtained.

(3) We are also looking to the tractor to achieve great things on the farm. It will allow considerable development of cultivation implements, enable us to improve our tillage and to keep down weeds, a very serious trouble in the southern part of England. Good Scottish farmers in that region have told me that farming in Scotland is much easier than in England, because the rigorous

northern winters keep weeds in check, while the mild southern winters encourage their growth.

(4) It is possible that certain substances, such as boric acid, the flourides, etc., studied by Gautier and Claussmann in France, may help in raising crop growth.

(5) It is possible also that special methods may prove of value, such as the high tension discharge tested by Miss Dudgeon at Lincluden, Dumfries, and ably and critically studied by Prof. V. H. Blackman.

(6) Finally, it seems probable that some wholly new method may be found for increasing crop growth. In most civilized countries there are now research institutes where the ways of plant and the properties of soils are being studied. Men of science, as a rule, do not care to risk prophecies or to attempt to create sensations, and I certainly am not going to break this wholesome rule. Something, however, has already been done; in spite of the decreased labour spent on cultivation, the yields tend to go up, while the new knowledge that is now being gained is adding greatly to the pleasure of farming and giving both masters and men an interest in their work that they never had before.

RESEARCH IN ANIMAL BREEDING.*

III.

BY

R. C. PUNNETT, F.R.S.,

Professor of Genetics, University of Cambridge.

In the previous articles of this series, published in the September and November 1921 *issues of the Journal, Prof. Punnett dealt with the coat colours in cattle, and the crossing of polled with horned cattle as illustrations of simple Mendelian inheritance.*

THE factorial hypothesis of heredity is, if substantiated, of fundamental importance to the breeder, for it at once raises the operations from an empirical to a scientific plane. It brings certainty where before was only conjecture. Consequently, when animal-breeding experiments were started on the University Farm at Cambridge in 1910, it was felt that among the first things to do was to choose one or two cases of apparent blending inheritance, and to study them critically in order to ascertain whether they could be interpreted on the factorial hypothesis. The choice of material was limited to small animals, for reasons of economy. This, however, was no drawback, for small animals can be bred in reasonably large numbers ; and we can hardly doubt that what we learn from them is applicable to bulkier and more costly stock. Our work has, therefore, been entirely with poultry and rabbits.

One of the most extensive series of experiments undertaken with poultry was designed to investigate the inheritance of

* Reprinted from *Jour. Min. Agri.*, XXVIII, no. 3.

weight. For this purpose two standard breeds were chosen, differing markedly in size, but not so much so as to prevent natural crossing. For the larger breed we selected the Gold Pencilled Hamburgh, and for the smaller one the Silver Sebright Bantam (Plate VIII, fig. 1). As will appear later, the reason for choosing these particular breeds was to make use of the same material for the elucidation of more than one problem. From the point of view of size the two breeds differed sufficiently, for the average weights of cocks and hens respectively were for the Hamburgh about 1,400 and 1,100 grammes, while for the Sebright they were about 850 and 650 grammes. Roughly the Sebrights were about 3/5ths of the weight of the Hamburghs.

The first cross birds were intermediate in size, though approximating to the larger breed, the cockerels averaging about 1,200 grammes and the pullets about 950 grammes. From several pens of such F_1 birds, an F_2 generation of 239 birds was raised, *viz.*, 113 cockerels and 126 pullets. In contrast to the uniformity of the F_1 generation these F_2 birds exhibited a wide range of variation. As shown graphically in Fig. 1, the weights of the cockerels varied from about 550 to 1,600 grammes, while those of the pullets were from 500 to 1,200. The majority of the birds in this generation were between the weights of the original parental breeds, but a few were larger than the Hamburgh, and a few were smaller than the Sebright (Plate VIII, figs. 2 and 3). Here we have an apparent case of blended inheritance, with fair uniformity in F_1, and a wide range of variation in F_2. Can such a case be interpreted in terms of the factorial theory ? An interpretation is possible if we suppose that the Hamburgh and the Sebright differ in several factors, each of which affects the weight of the bird. The explanation of such cases was first given by Nilsson-Ehle, the well-known Swedish plant breeder, to account for the results of certain of his experiments with wheat and oats at Svalof. The closeness with which the theory fitted his results left little doubt of its being a true interpretation. The essential part of his idea is that a similar effect may be brought about by more than

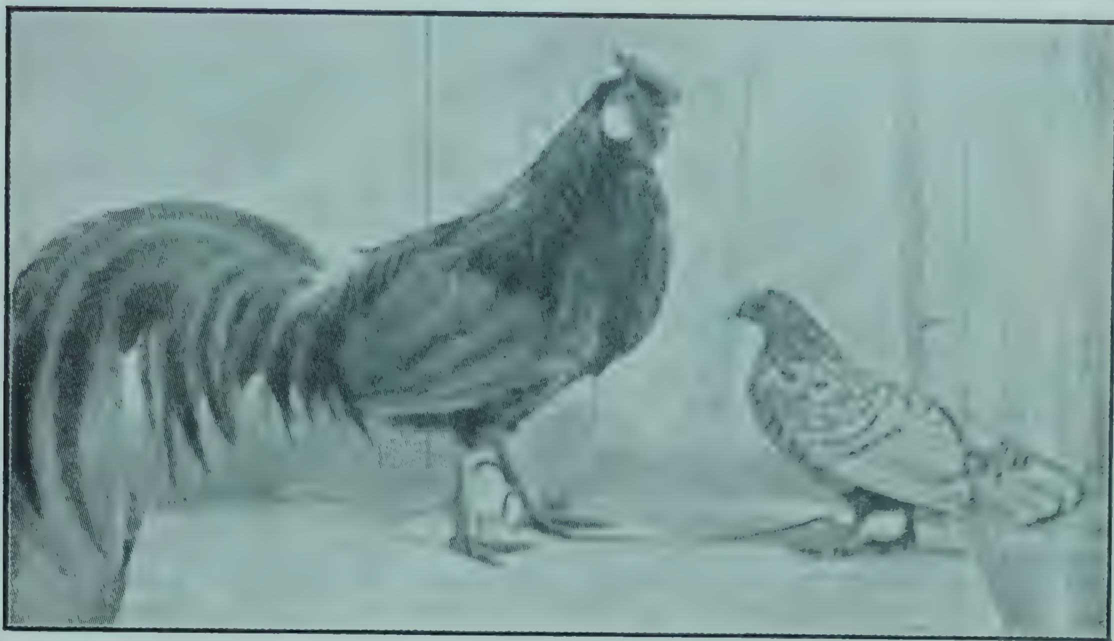

Fig. 1. Gold-pencilled Hamburgh cock and Silver Sebright hen.

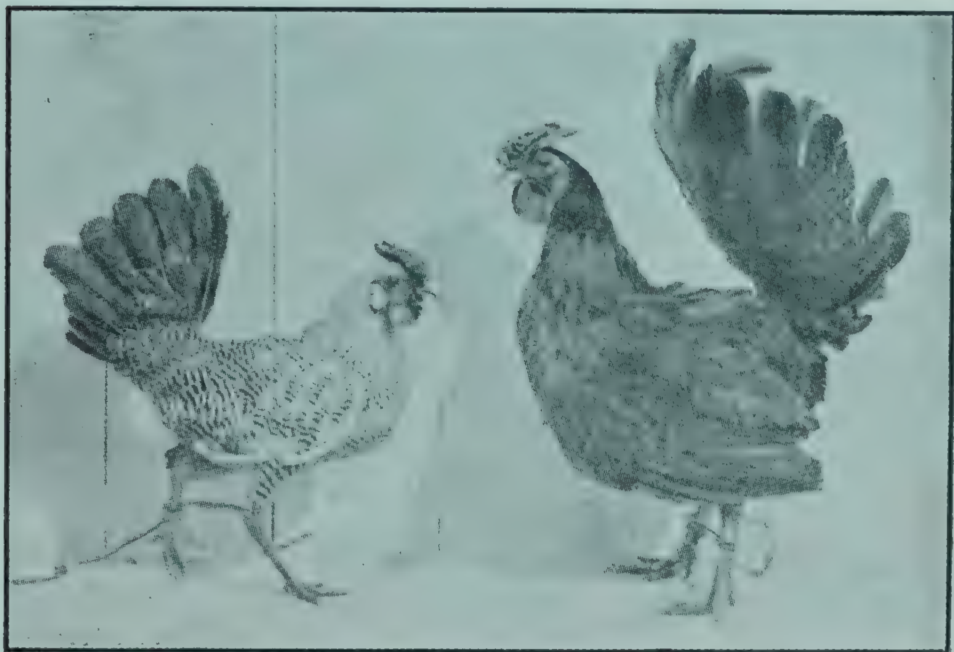

Fig. 2. Small and large F_2 cockerels.

Fig. 3. Small and large F_2 pullets.

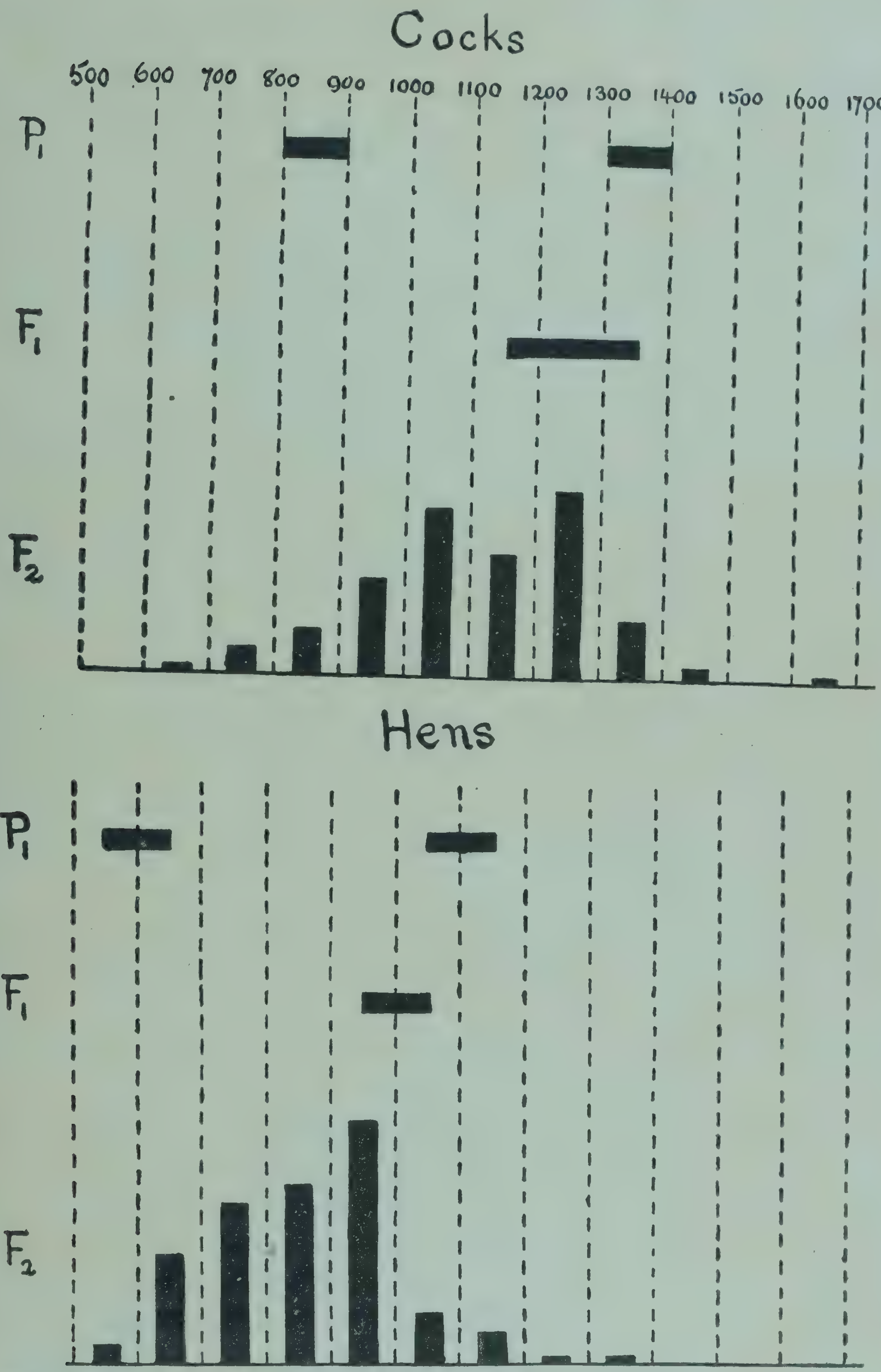

FIG. 1. Illustrating the inheritance of weight in the Hamburgh-Sebright cross. The figures at the top represent the weight in grammes. For further explanation see text.

one factor, though such factors are independently transmitted in the usual way.

Let us suppose that there are several similar factors A, B, C, D, etc., which influence the weight of poultry. When a bird possesses none of these factors it will be the smallest type of bantam; when it contains A it will be rather larger; when it contains both A and B it will be larger again, and so on until the largest breed is reached, which must be supposed to contain a full collection of these factors. Again, let us suppose that when a bird is pure for one of these factors, *i.e.*, when it has received it from both parents, the effect on its weight is greater than when it has received it from one parent only. In other words, we suppose that dominance is not complete and that the Aa bird, for example, is not so heavy as the AA bird of otherwise similar constitution. And so also for the other weight factors B, C, D, etc.

Now if we suppose that the Hamburgh contained three such factors, A, B and C, while the Sebright contained a different one, *viz.*, D, we obtain a theoretical explanation which covers the observed facts :—

(1) The uniformity of the parental breeds for a markedly different average weight.

(2) The uniformity of the F_1 birds in weight.

(3) The approximation of the F_1 birds to the weight of the larger parent.

(4) The great variation in weight shown by the F_2 generation.

(5) The production in F_2 of birds larger than the Hamburgh, and of others smaller than the Sebright.

For if the Hamburgh were $AABBCCdd$, and the Sebright $aabbccDD$ the F_1 birds must all be $AaBbCcDd$. They will be uniform, and at the same time, since they contain a dose each of 4 factors, they will not on our hypothesis be much lighter than birds which, like the Hamburgh, contain a double dose of 3 factors. When, however, such birds are bred together they should give an F_2 generation showing great variation, for such F_1 birds should

produce germ cells of 16 different kinds with respect to the four size factors involved, *viz.*,—

ABCD	*AbCD*	*aBCD*	*abCD*
ABCd	*AbCd*	*aBCd*	*abCd*
ABcD	*AbcD*	*aBcD*	*abcD*
ABcd	*Abcd*	*aBcd*	*abcd*

From the meeting of two such series of germ cells it is clear that all sorts of sizes will result ; but the reader who wishes to follow out these possibilities in detail must be referred to the original paper.[1] It should, however, be noticed that such a combination as *AABBCCDD* will occur, in which a bird is pure for all 4 factors. Birds of this combination, as well as others such as *AABBCCDd* or *AABBCcDD*, should be heavier than the Hamburgh. Again, we may have the combination *aabbccdd* in which none of the 4 factors are found. Such birds must be smaller than the Sebright.

The theory is in accordance with the series of facts to be explained that was set out before. It can, however, be subjected to further test. The very large F_2 birds, and the very small ones should, on the theory, breed true to size. Lack of opportunity prevented the testing of the biggest ones, but a pair of the smallest F_2 birds (Plate VIII, figs. 2 and 3) was mated together, and found to breed true to the unusually small size. Lastly, among the birds of intermediate size there should be some which are pure for 2 factors, *e.g.*, *AABBccdd*, which should breed true to a size intermediate between that of the Hamburgh and the Sebright. Recent tests have revealed the existence of such birds.

This series of experiments suggests that even so complicated a character as that of weight, where inheritance is seemingly of a blended nature, can nevertheless be interpreted in terms of definite factors, each producing a definite effect. It is not of course suggested that weight is dependent solely upon such factors. Absolute uniformity, even where animals are of the same genetical

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[1] "On Inheritance of Weight in Poultry," by R. C. Punnett and P. G. Bailey. *Journal of Genetics*, IV, 1914.

constitution, cannot be expected. For no two animals can be treated exactly alike with respect to food and other conditions. Moreover, it is conceivable that other factors, influencing vigour as distinct from weight, may come into operation, and produce some effect upon weight itself.

The results are not without interest in connection with the problems of in-breeding and the effects of a cross. Close in-breeding is held by some to lead to deterioration in the matter of size, and there is certainly some foundation for this belief. Yet it is by no means certain that, sometimes at any rate, this deterioration is not due to the fact that the original material was impure in some of the size factors, and that one or more of these may have been eliminated by unconscious selection. Again, there is much evidence to suggest the view that first-cross animals frequently make unusually good growth, and exceed both parental strains in weight. By some this effect is referred to the increased vigour resulting from a cross. This, of course, is no explanation, so long as we cannot state precisely how this increased vigour is brought about. It may be that there are definite factors working for vigour, though at present this has not been experimentally proved. The poultry results force us to recognize that increased size in first crosses may be due to a cumulative effect of different size factors brought in by the two parental breeds.

The two strains *AABBccdd* and *aabbCCDD* would each be of intermediate size, and nearer in this respect to the Sebright than to the Hamburgh. First-cross birds between these two would be in constitution *AaBbCcDd*, *i.e.*, of the same constitution as the F_1 Hamburgh-Sebrights. They would be larger than either of the intermediate parental strains, but this increase would not be due to vigour incidental to a cross, but to the cumulative effect of the 4 factors *A*, *B*, *C*, *D*, of which two were brought into the cross by each parent. Moreover, such F_1 birds might be expected to give a small proportion of progeny larger than themselves, and breeding true to this increase in size. Where a notable increase in size follows on a cross, it suggests that the breeds used contained different size factors ; and if this were so, it would be possible to establish a strain

of increased size by working on the lines indicated by the factorial theory.

Suggestive as the poultry experiments are, we recognize that we are only at the beginning of this kind of enquiry. Some experiments of a similar nature with rabbits gave a different result.[1] A cross was made between the Polish, which is the smallest of the breeds of domesticated rabbits, and the Flemish, which is one of the largest. The Polish was used as the father of the F_1 animals, which were intermediate, and fairly uniform in size (Fig. 2). From

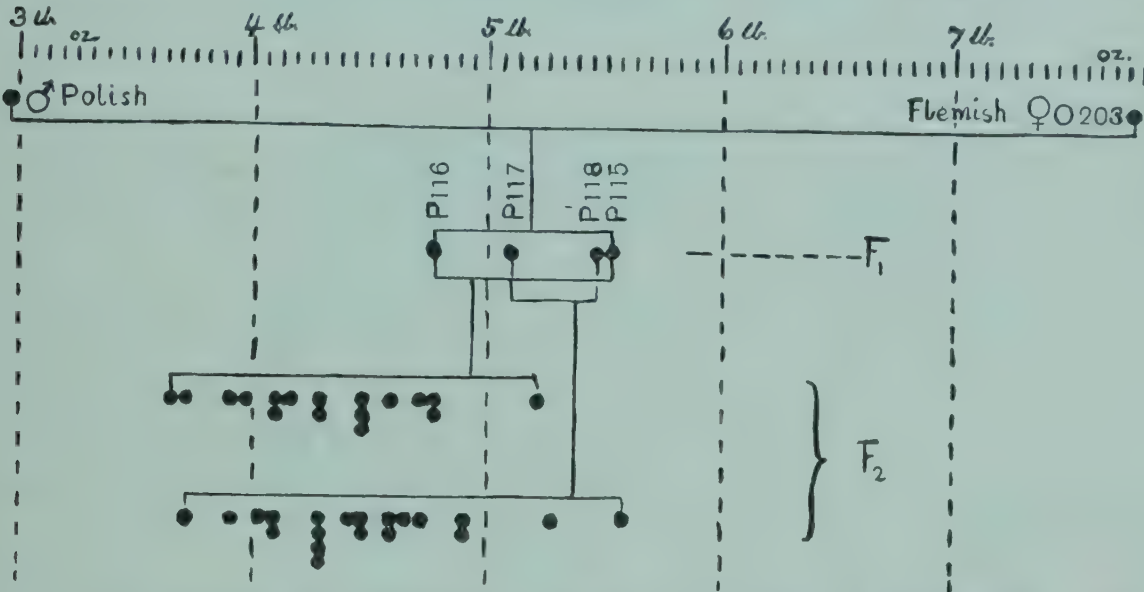

Fig. 2. Illustrating the inheritance of weight in a Polish × Flemish cross. Each individual is represented by a dot on the chart according to its weight in lb. and oz. Thus, the F_1 animal P 116 weighs 4 lb. 13 oz., and P 117 weighs 5 lb. 2 oz.

two pairs of such F_1 animals an F_2 generation was raised. Owing to lack of accommodation the total number of offspring reared was only 37. Nevertheless this F_2 generation shows a remarkable feature in that the size of the F_1 animals was not exceeded, although some were nearly as small as the Polish parent. The absence from the F_1 generation of anything approaching the size of the Flemish is highly puzzling, and no explanation can at present be offered. The experiment is being repeated with the difference that the F_1 animals have been bred from Polish doe × Flemish buck, instead of in the reverse way as before.

[1] "Genetic Studies in Rabbits, 1. On the Inheritance of Weight," by R. C. Punnett and the late P. G. Bailey. *Journal of Genetics*, VIII, 1918-19.

When planning investigations on these cases of apparently continuous variations it was felt desirable to choose another example of a different type. Accordingly a " pattern " case was selected in rabbits. Here, as in many of the domesticated animals, we encounter white markings, and the extent of these is very variable. We can in fact obtain a continuous series in the rabbit, ranging between the self-coloured animal with a touch of white on the nose or on a paw, and an animal completely white except for a touch of pigment round the eye and at the root of the tail (Plate IX, fig. 3). Such a continuous series can in fact be bred in the F_2 generation from a cross between a self-coloured animal and one of these almost white ones. The problem here again was to determine whether such an apparently continuous series could be expressed in terms of a few definite factors, or whether some other explanation had to be sought.

The case was of more than usual interest because Professor Castle, working at a similar case in rats, had put forward the view that the factor itself could be changed by " selection." Were this view upheld by experimental research it is evident that we should have to give up the conception of the relative permanence of the factor which forms the basis of the factorial theory, and with it that hope of control over breeding operations which the definite and permanent factor signifies. The results of our experiments with rabbits did not bear out Professor Castle's view. We found that a comparatively simple interpretation on factorial lines would cover the facts.[1] Moreover, Professor Castle himself has recently given up his earlier view, and considers that an orthodox explanation, in terms of the factorial theory, is adequate. We have mentioned the case here because the idea that the factor can be influenced by " selection " is to be found in text-books that are widely read. It may serve to prevent misunderstanding if it is realized that the view is no longer supported by its originator.

As we have already stated, a cross between a self-coloured animal and a " White Dutch " gives F_1 animals with a small but

[1] "The Genetics of the Dutch Rabbit—a Criticism," by R. C. Punnett. *Journal of Genetics*, IX, 1920.

Fig. 1. Rabbit with Dutch pattern.

Fig. 2. Spotted Dutch rabbit.

Fig. 3. White Dutch rabbit.

varying amount of white, and in F_2 a full range from Self to White Dutch. In such a series, however, the gradual increase of the White occurs in a more or less orderly fashion. It begins with the tip of the nose or muzzle, the tips of the fore-paws, and the "blaze"; it then invades the neck, shoulders and fore-limbs; at a more advanced stage we reach the typical pattern of the Dutch rabbit (Plate IX, fig. 1); later on the pigmented area round the eyes is reduced and the coloured area of the body becomes patched with white giving rise to the "spotted Dutch" (Plate IX, fig. 2); further reduction of the pigment eventually results in the White Dutch (Plate IX, fig. 3).

A long series of experiments has shown us that 3 pattern types corresponding to Dutch, Spotted Dutch, and White Dutch can be got to breed approximately true. The more pigmented tends to be dominant to the less pigmented, but as a rule dominance is far from complete, so that various intermediate forms arise. Two pairs of factors *T-t* and *S-s* serve to interpret the range of forms between Dutch and White Dutch, Dutch being *TTSS*, Spotted Dutch *ttSS*, and White Dutch *ttss*.

The relation of all these to the more heavily pigmented grades is determined by another factor *P*; its presence represents much increased pigmentation. A single dose of *P* added to White Dutch transforms the animal into one with a pattern resembling the Dutch*; added to Spotted Dutch, it leads to a grade of pigmentation between Dutch and self-colour; added to Dutch, it results in an animal that is almost or quite self-coloured. Where the animal is *PP* the White area is further diminished, but the difference between *PP* and *Pp* animals has not yet been fully worked out.

The outstanding fact in connection with these patterns is that analysis of this continuous series, from self to almost white, has provided an interpretation in terms of the factorial theory; and that, too, in terms of but 3 factors.

* The *Ppttss* animal may be indistinguishable from the *ppTTSS* animal in appearance but the two breed very differently.

Notes

THE POSSIBILITIES OF *RABI* CROPS IN ORISSA.

One of the problems of agriculture in Orissa is no doubt the cultivation of the flooded tracts. This problem has of late years assumed serious proportions on account of frequent failure of the paddy crop over vast areas caused by high and destructive floods. It was, therefore, decided to consider if a change of crops could not be recommended for these areas. With this view the Agricultural Department last year undertook some experiments both at the Cuttack farm and at two other typical flooded areas to test the suitability of *rabi* (winter) crops to the climatic condition of Orissa in general and to the soil condition of the flooded tracts in particular.

Of the two flooded areas where experiments were conducted, one was situated at Singapur near Jenapur where one acre and a half of land were acquired from the Raja of Madhupur for this purpose on the 29th of September, 1920. This land was previously sown with paddy which was completely destroyed by the high flood of the Brahmani which occurred in the third week of July and continued till the second week of August. As a result of the flood there was a rich deposit of coarse silt. In October the land was ploughed and cross-ploughed several times to bring it under fine tilth, and on the 1st of November the seeds were sown. All the crops were ready for the sickle within the month of March. The following table shows the crops sown, their area and yield and their yield per acre.

Serial No.	Name of crop	Area sown	Yield obtained			Yield per acre		
		Acre	Md.	Sr.	Ch.	Md.	Sr.	Ch.
1	Wheat (local)	0·1	1	22	0	15	20	0
2	Wheat (Pusa 4)	0·1	1	32	12	18	7	8
3	Barley (local)	0·16	3	0	0	18	30	0
4	Barley (Bihar)	0·1	1	30	0	17	20	0
5	Oats (Bihar)	0·1	2	15	0	23	30	0
6	Gram (Bihar)	0·1	1	23	6	15	33	12
7	Patna Pea (Bihar)	0·1	2	0	0	20	0	0
8	Lentil (Bihar)	0·1	1	7	8	11	35	0
9	Mustard (local)	0·12	0	37	0	7	28	0

From the above table it will be seen that the yield of the crops grown at Singapur can compare very favourably with the average yield of these crops in other parts of the province where they are normally cultivated. It should be mentioned that only *desi* ploughs and local bullocks were employed in preparing the land, that no manure or irrigation was given to the crops, and no weeding was necessary. The cost of cultivation, including harvesting and threshing, came to about Rs. 15 per acre.

At the Cuttack farm, in comparatively poor soil, Pusa wheat No. 4 gave an outturn of 10 maunds 30 seers per acre with two irrigations from the canal, and gram gave an outturn of 11 maunds 35 seers per acre without any irrigation or manuring.

From the above it will be seen that neither the climatic condition of Orissa nor the soil condition of the flooded tracts is unsuitable for the cultivation of *rabi* crops, and that when the paddy has failed the cultivation of these crops may be recommended without much hesitation. Of course, the soil condition of the flooded tracts is not the same everywhere. It can be divided in a general way into three classes, namely, (1) sandy, (2) loamy and (3) clayey with intermediate stages. The yield of the crop depends to a very great extent on the quality of the soil, loams being better than clays, while sandy soil is generally unsuitable. But the most important condition for the success of *rabi* crops is the conservation of moisture. Timely and thorough preparation of the land is essential and too much stress cannot be given to this point. At Singapur, in the immediate neighbourhood of our land, the cultivators had also grown local wheat. But they prepare their land indifferently,

giving it only two or three superficial ploughings, with the result that whereas we obtained a yield of 15½ maunds per acre with well-developed, plump grain, they barely obtained a yield of 8–10 maunds per acre of immature, shrivelled grains, though we used the same seeds as they did. This difference is undoubtedly due to their bad preparation of the land and its consequent loss of moisture. Although they might have made a saving of Rs. 4 or Rs. 5 in the cost of cultivation, they lost a great deal of the profit.

Apart from the usual risks in the cultivation of *rabi* crops such as are due to changes of weather, the short and mild winters of Orissa, which though do not actually militate against the adoption of *rabi* cultivation, are factors which are likely to interfere with its success to some extent. Hence sowing should not be done until the first week of November and as far as possible early varieties of crops, such as Pusa wheat No. 4, should be selected instead of those which take longer period to mature their seeds. Also arrangements will have to be made to prevent cattle trespass which seems to be a matter of some difficulty. [S. K. BASU.]

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SHAHJAHANPUR SUGARCANE NO. 10.

IT will interest many readers of "The Agricultural Journal of India," especially sugarcane growers in the Punjab and Western U. P., to know that a variety of sugarcane, called Shahjahanpur No. 10, sent to Australia from the Shahjahanpur Sugar Experiment Station of the United Provinces, has been found to resist severe frosts remarkably well. Mr. Easterby, Superintendent of the Queensland Bureau of Sugar Experiment Stations, reports that its sugar content and keeping qualities being good it was distributed to a considerable extent in Southern Queensland. According to this officer's memorandum published in "The Australian Sugar Journal," dated the 13th September, 1921, on a recent visit to Bundaberg, his attention was directed to a very fine block of this variety, about 12 acres in extent, which had been grown at Spring Hill by the Fairymead Sugar Company under the charge of Mr. Axam. This cane was then only nine months old, but presented

a splendid vigorous growth. Mr. Axam declared that in his experience with the cane it had never been affected by frost and this was borne out by Mr. Pringle, Chemist in charge of the Bundaberg Sugar Experiment Station. If this cane maintains its reputation, it should be extremely valuable to cane growers who suffer from frost. The last analysis of the cane, made at the Bundaberg Station last year, gave the following results :—Brix, 21·7 ; Purity of juice, 91·0 ; percentage of fibre in cane, 13·6 ; commercial cane sugar, 15·05. [WYNNE SAYER.]

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MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA.

IN view of the fact that returns supplied by Indian sugar factories are far from complete, the figures for the working season of 1919-20 published in "The Agricultural Journal of India," September 1921, have been carefully checked with the returns for the season 1920-21 with the result that certain discrepancies have been cleared up. The revised figures of the production of sugar, amount of cane crushed and the quantity of molasses turned out during the working seasons of 1919-20 and 1920-21 are given in the subjoined table. It is proposed, as the figures in returns become more complete, to revise the totals from time to time as it is found necessary.

Table showing total production of sugar by factories crushing cane. Seasons November to April, 1919-20 *and* 1920-21.

	CANE CRUSHED		SUGAR MADE		MOLASSES OBTAINED	
	1919-20	1920-21	1919-20	1920-21	1919-20	1920-21
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
Bihar and Orissa	5,439,618	6,577,083	375,746	465,100	186,251	261,620
United Provinces of Agra and Oudh	2,140,797	2,547,871	140,241	156,777	114,504	119,231
Other Provinces of India	1,617,611	606,461	112,933	47,414	70,198	23,861
Total for India	9,198,026	9,731,415	628,920	669,291	370,953	404,712

[WYNNE SAYER.]

COMBINED MOTOR THRESHER.

We are indebted to Lieutenant J. L. Flowerdew, Officer in charge of the Military Farm, Okara, Montgomery District, Punjab, for an interesting description of work of a Combined Motor Thresher—a 24" Bon Accord Thresher coupled with a 5 H.P. Petter Oil Engine—on a crop of wheat on that farm. The first trial, owing to the fact that the crop was harvested in accordance with the practice prevalent in that part of the country, that is, in bundles too heavy to be easily passed on to the thresher, was unsuccessful, the outturn being only about 40 maunds of grain a day. In the second trial, the bundles were broken up into small size sheaves, 7 lb. to 8 lb. each, which could be conveniently passed with hand forks on to the thresher, and the outturn was at the rate of 160 maunds of clean grain per day, equivalent to ten days' work by the country method. There was, however, no appreciable difference in the cost of the two methods.

The results are not very convincing, and a fuller trial of the thresher is therefore necessary to arrive at definite conclusions as to its suitability for adoption by zemindars of the Montgomery District. Lieutenant Flowerdew is of opinion that to suit the local requirements, the theresher should contain a bruiser for reducing straw to *bhoosa*, and that it should be constructed of structural steel instead of wood, as the latter will not stand the Indian heat without warping.

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TANKS *VERSUS* WELLS.

We have received from Mr. S. K. Gurtu, Member for Irrigation, Board of Revenue, Gwalior, the following contribution to the long standing controversy whether tanks are more suitable than wells in Central India for the development of cultivation :—

" Some people have an idea that in the long run it is cheaper to construct and work wells in Central India than storage reservoirs. This opinion is formed without collating facts and figures.

The cost of storage in Central India, on an average, is from Rs. 1,000 to Rs. 1,500 per million cubic feet. One million cubic

feet irrigate from 10 to 20 acres. We may take 15 acres as an average. Thus the capital cost of irrigating an acre is Rs. 1,500/15 = Rs. 100. The cost of constructing a well is a much more variable factor. It varies from Rs. 2,000–Rs; 10,000 according to the depth of the sub-soil water level and the nature of the substrata. In northern Gwalior the substratum is alluvial and the cost of digging is not very great, but owing to the depth of the wells, which varies from 40 to 80 feet, the cost of steining is rather high. In other portions of Gwalior like Sheopur and Isagarh and Malwa, steining is generally not required owing to the presence of rock of varying hardness in the substrata, but the item of rock blasting is a very costly one. Thus either way a deep well is an expensive affair. I have had to construct numerous wells in different localities in Central India and know that the over-all cost varies from Rs. 2,000 to Rs. 10,000. Besides, when the depth of the water is more than 60 feet below the surface, the cost of lifting it by bullock power is prohibitive and irrigation becomes impracticable. Leaving out for the present this aspect of the question, and confining ourselves to the item of capital cost alone, we may assume that an ordinary irrigation well costs about Rs. 3,000 on an average. The potential duty of a well varies from 2 to 3 acres. Assuming it to be 3 acres (the maximum) per well and taking the minimum of expenditure, the capital cost of irrigating per acre is Rs. 3,000/3 = Rs. 1,000 against Rs. 100 by flow.

"Apart from the question of capital expenditure, the working cost makes all the difference to the irrigator. In irrigating from a tank by flow, the charge for irrigation per acre to the cultivator is Rs. 3, whereas to irrigate 3 acres from a well the cultivator has to undergo the following expenses :—

	Rs.
'Charsa' (leather) which lasts a season	12
Feed of oxen for 4 months	48
Bullock driver " " "	24
Ropes and sundries	6
	90

"This gives an average figure of Rs. 90/3 = Rs. 30 per acre as cost of watering from a well against Rs. 3 per acre from tanks. This will show that, from considerations both of capital cost and recurring

expenditure, irrigation by flow is ten times cheaper than by lift from wells.

"The above assumes that every well sunk to a depth of 60 feet, on an average, will yield sufficient water. The writer's past 20 years' experience goes to show that, with the exception of wells constructed in riparian tracts, they do not yield sufficient replenishment, unless they are situated under tanks which, even if they do not fill up to brim in years of drought, keep up active percolation in the wells through sub-soil infiltration, for even when the bed of a tank is dry its substrata, from 6″ to 12″ below the bed, remain fully charged with water, and this accounts for wells below tanks not failing even in years of drought. It may be urged that as wells are more unfailing in their supplies in years of drought than tanks they should be preferred on the score of protection. This does not necessarily follow, because scarcely 1 per cent. of wells last out a summer and they almost all fail in years of drought, unless situated below tanks or near flowing drainage courses. Wells with adequate replenishment, such as will not fail even in years of drought, are few and far between.

"There is yet another factor in favour of tanks. Irrigation from tanks sets free thousands of labourers and draft cattle employed on water lifting from wells which can be more suitably employed elsewhere and leads to increase in general prosperity.

"Though tanks are cheaper and more efficient than wells, the former cannot wholly be substituted for the latter. The construction of embankments and boring of wells should go together and would be of material advantage to each other. Whenever good sites are available, we should, in the first instance, construct a tank or tanks commensurate with the requirements of the tract, followed on with wells dotted over the commanded area. In this way the cultivators will derive benefit from the combination of both, in normal and dry years.

"There are localities, notably in hilly tracts and very flat plains, where sites for tanks and reservoirs are not available. For such localities wells are clearly indicated, both for extension of cultivation and partial protection from famine—partial because the scope of

wells is rather limited. It will be seen that it is not correct to try to institute comparison between the advisability of construction of tanks or wells. One thing may be more valuable and useful than the other and yet both may be necessary. Construct tanks and construct wells, and yet more wells if you like, but exercise proper discrimination.

"The decision whether a particular tract should be protected by tanks or wells, or both, is one to be considered on its merits, into which configuration of land, nature of rainfall, surface slopes, class of soil and so many other factors enter. It is not a matter about which any one can light-heartedly dogmatise."

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ROYAL CHARTER GRANTED TO EMPIRE COTTON GROWING CORPORATION.

It is announced that the King in Council has approved the grant of a Charter to the Empire Cotton Growing Corporation. The Corporation is the permanent body which is being set up to carry into effect the recommendations made by the Empire Cotton Growing Committee. This Committee was appointed by the Board of Trade in 1917 to enquire into the possibilities of cotton production within the British Empire, in the hope that by fostering the growth of cotton in the Dominions and Colonies the industry in this country might be made less dependent upon the United States for the greater portion of its supply of raw material.

The object of the Corporation will be to extend the cotton growing areas of the Empire and thus both promote the development of the Dominions and Colonies and also assist in the stabilization of prices by drawing on a number of new areas far distant from each other, in addition to the American cotton belt, thus making the supply of raw material less dependent on climatic conditions in one part of the world. A bad season in one part of the Empire will, it is hoped, be counteracted by good crops in other British possessions, whilst Lancashire will also be enabled to view with less concern America's ever-increasing consumption of her own crop.

Under the Charter the Corporation will, amongst the other functions, have power to carry out the following work :—

(1) To assist in the enlargement and strengthening of the Agricultural Departments of the Dependencies and Colonies, and to provide facilities for training men for posts under these departments.

(2) To establish a Bureau for the dissemination of information on cotton growing, and to issue a Journal containing useful information on the subject.

(3) To undertake the marketing of crops where this will prove of assistance to the Local Governments ; this work will doubtless be done in conjunction with the British Cotton Growing Association.

As has already been announced, the Corporation will be financed by means of the grant of approximately £1,000,000 which has been made by the Government, and by a levy imposed by spinners on the raw material used in this country.

The affairs of the Corporation will be in the hands of an Administrative Council, the Presidency of which has been accepted by Lord Derby. The following gentlemen also have agreed to become the first Vice-Presidents of the Council:—Lord Ashfield, Lord Colwyn, Lord Emmott, Lord Lovat, The Rt. Hon. Sir Frederick Lugard, The Rt. Hon. Walter Runciman, Sir Frank Forbes Adam, Sir Henry Birchenough, Sir Edward Tootal Broadhurst, Sir Frank Hollins, The Hon. Sidney Peel, M.P., Mr. Thomas Shaw, M.P., and Mr. J. Arthur Hutton. [*The Board of Trade Journal*, 20th October, 1921.]

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THE YIELD OF EGYPTIAN COTTON.

In the current number of the Bulletin of the Imperial Institute (XIX, 2), Mr. Gerald C. Dudgeon, C.B.E., lately Consulting Agriculturist to the Government of Egypt, discusses the causes which have led to the decline in the yield of cotton in Egypt. Whereas during the six years ending 1899 each acre under cotton produced on

the average an annual crop of over 500 lb. of cotton, during the eight years ending 1913 the average yield had fallen to just over 400 lb., and in 1920 it was as low as 320 lb. per acre, the reduction in twenty years thus amounting to 36 per cent. Such a decline, if not checked, must in time have a serious effect on the prosperity of Egypt which depends so largely on the cotton-growing industry. It is pointed out that although the chief causes to which the decline is due have been recognized, the proportionate share of each in the result is often so unduly emphasized as to produce a misleading impression, and this is apt to lead to the adoption of incorrect procedure. In the article in question, Mr. Dudgeon places in their true perspective the different factors involved, such as the degeneration of the productive powers of the soil, the ravages of insect pests, and agrarian disturbance. He considers that great improvement would result from the completion of the comprehensive drainage scheme, which was inaugurated by the indefatigable energy of the late Lord Kitchener but was delayed by the War.

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THE FERTILIZER INDUSTRY AND NAURU PHOSPHATE.

THE manner in which the supplies of phosphate from Nauru Island will be divided among fertilizer manufacturers is evoking much interest; the companies that will be most affected are the Mount Lyell Co. in Tasmania, and the Australian Fertilizers Co. in New South Wales. Discussions are now taking place between the Electrolytic Zinc Co. of Australasia, Ltd., and superphosphate manufacturers with a view to utilizing the sulphur produced in the roasting of zinc concentrates. At present the zinc company is not working at full capacity, and its plant will not be completed for some time, but when in full operation sufficient sulphur will be available to provide for two-thirds of the superphosphate requirements of the whole of Australia, thereby rendering unnecessary the importation of sulphur from America and Japan. [*The Journal of the Society of Chemical Industry*, August 31st, 1921.]

CHANGES IN CYANAMID.

In the November (1920) issue of "The Journal of Industrial and Engineering Chemistry" there appears a paper by N. R. Harger on the changes taking place in cyanamid when mixed with fertilizer material. A great deal of research has been done on changes which take place when cyanamid alone is added to the soil or is kept in storage, but relatively little attention has been paid to changes which may occur in the material when this extremely reactive substance is mixed with the other fertilizer materials. There has been indication in some areas that mixed fertilizer containing cyanamid is somewhat toxic to plants but heretofore no experiments on the question have been reported. In the experiments under discussion the following mixtures were used : (1) acid phosphate and cyanamid ; (2) potassium sulphate, acid phosphate, and cyanamid ; (3) ammonium sulphate, acid phosphate, and cyanamid ; and (4) dried peat, acid phosphate, and cyanamid. The paper discusses the chemical changes involved and gives experimental details together with analysis, the author having devised a rapid method which is direct, for the determination of dicyanodiamide which has been found to be the substance into which cyanamid is changed under the conditions obtained. While further investigations are under way, the results which so far have been ascertained lead the author to reach the following conclusions :—

"1. When cyanamid is mixed with fertilizer materials containing acid phosphate and 5 to 10 per cent. of moisture, the cyanamid content decreases with great rapidity.

"2. This change is represented partially by, and in the higher concentrations principally by, the formation of dicyanodiamide.

"3. A given quantity of moist acid phosphate is able to transform a limited amount of calcium cyanamide.

"4. Cyanamid is not affected by dry acid phosphate.

"5. Moisture alone is able to cause the conversion of cyanamide to dicyanodiamide, but the change is much slower than when acid phosphate is present.

" Since it has been repeatedly shown that dicyanodiamide is valueless as a fertilizer material, and, moreover, is toxic to many plants, the formation of this compound in fertilizer materials seems undesirable. On first thought, it would appear that this conversion of cyanamide into dicyanodiamide could be avoided by employing dry fertilizer mixtures but this overlooks the fact that when such mixtures are added to the soil, moisture conditions are at once provided, and the transformation may possibly then take place. Preliminary experiments carried out in this laboratory indicate that, under certain conditions at least, this is the case.

" It should be noted that these unfortunate reactions between acid phosphate and cyanamid do not in any sense imply that cyanamid cannot be successfully used when mixed with other forms of phosphate. In this connection it should be noted that the Fixed Nitrogen Research Laboratory of the Ordnance Department has called our attention to the fact that lime nitrogen (cyanamid) can be mixed with calcined and basic phosphates without the excessive production of dicyanodiamide noted when moist acid phosphate is used." [*Scientific American Monthly*, III, no. 1.]

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RESEARCH ON NITROGEN FIXATION.

THE sum of $500,000 has been made available for two years for the continuation of research work on fixed nitrogen. The Fixed Nitrogen Research Laboratory at American University, Washington, with a staff of 120, has been transferred from the War Department to the Department of Agriculture. [*The Journal of the Society of Chemical Industry*, August 31, 1921.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

DR. W. H. HARRISON, Imperial Agricultural Chemist, has been appointed Joint Director of the Agricultural Research Institute, Pusa, from the 10th December, 1921.

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MR. R. C. T. PETTY, who has been appointed to the Indian Agricultural Service, has been posted as Assistant Agricultural Bacteriologist in the Imperial Department of Agriculture from 19th November, 1921.

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THE appointment of Protozoologist in the Imperial Department of Agriculture, held by Dr. A. P. Jameson, is terminated from the 17th October, 1921.

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THE office attached to the appointment of Imperial Cotton Specialist in the Imperial Department of Agriculture is closed from the 9th August, 1921.

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DR. J. N. SEN, Supernumerary Agricultural Chemist, Pusa, was on privilege leave for three months and ten days from the 14th September, 1921.

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MR. J. T. EDWARDS, B.Sc., M.R.C.V.S., took over charge of the office of Director and First Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, on the 19th November, 1921.

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MR. R. CECIL WOOD, M.A., on return from leave, has been appointed Principal and Professor of Agriculture, Agricultural College, Coimbatore, and Superintendent, Central Farm, Coimbatore.

Mr. D. Ananda Rao, B.Sc., has been appointed Assistant to the Principal and Professor of Agriculture, Agricultural College, and Superintendent, Central Farm, Coimbatore.

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Dr. Roland V. Norris, on return from leave, has been appointed Government Agricultural Chemist, Madras.

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On relief by Dr. Norris, Rao Saheb M. R. Ramaswami Sivan has been appointed Government Lecturing Chemist, Madras.

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Mr. E. Ballard, B.A., Government Entomologist, Madras, was on privilege leave for 19 days from the 1st November, 1921, Mr. T. V. Ramakrishna Ayyar holding charge.

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Mr. D. Balakrishna Murti Garu, Mr. S. Sundararaman, M.A., F.L.S., and Mr. G. N. Rangaswami Ayyangar, B.A., of the Madras Agricultural Service, have been promoted to the Indian Agricultural Service and appointed Deputy Director of Agriculture, Government Mycologist and Millets Specialist, Madras, respectively.

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Mr. P. C. Chaudhuri has been appointed to the Indian Agricultural Service as probationary Deputy Director of Sericulture, Bengal, from the 17th October, 1921.

***

Mr. G. G. Howard, M.R.C.V.S., D.V.H., has been appointed to the Indian Civil Veterinary Department from the 30th September, 1921, and posted to Bihar and Orissa.

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Mr. C. P. Mayadas, M.A., B.Sc., Offg. Deputy Director of Agriculture, Western Circle, Central Provinces, whose services have been placed at the disposal of the Government of the United Provinces, has been appointed Professor of Agriculture, Agricultural College, Cawnpore.

Mr. W. H. Cossar has been appointed Second Agricultural Engineer to the Government of the United Provinces from the 1st November, 1921.

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On return from leave, Mr. W. Taylor resumed charge of his duties as Professor of Pathology and Bacteriology in the Punjab Veterinary College, Lahore, on the 1st October, 1921, relieving Captain K. J. S. Dowland, Professor of Parasitology, of the additional charge.

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Captain S. G. M. Hickey, Second Superintendent, Civil Veterinary Department, United Provinces, has been granted combined leave for nine months from the 1st November, 1921, Captain W. H. Priston, Third Superintendent, holding charge.

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Mr. S. G. Mutkekar, Assistant Director of Agriculture, Western Circle, is appointed to officiate as Deputy Director of Agriculture, Western Circle, Central Provinces.

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Mr. J. N. Chakravarti, Deputy Director of Agriculture, Assam, has been granted an extension of leave by two months, Srijut Laksheswar Barthakur officiating.

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The Ninth Meeting of the Indian Science Congress will be held in Madras from 30th January to 3rd February, 1922. His Excellency Lord Willingdon, Governor of Madras, has consented to be Patron of the meeting, and Mr. C. S. Middlemiss will be President. The following Sectional Presidents have been appointed: Agriculture, Rai Bahadur Ganga Ram; Physics and Mathematics, Mr. T. P. Bhaskara Shastri; Chemistry, Dr. N. R. Dhar; Zoology, Mr. S. W. Kemp; Botany, Dr. W. Dudgeon; Geology, Mr. G. H. Tipper; Medical Research, Major Cunningham; Anthropology, Rai Bahadur Hira Lal. Public Lectures will be delivered by Prof. Hemchandra Das Gupta, Dr. de Graaf Hunter, and Prof. J. Matthai

Reviews

Cane Sugar: A Text-book on the Agriculture of the Sugarcane, the Manufacture of Cane Sugar, and the Analysis of Sugar-house Products.—By NOEL DEERR. Second (revised and enlarged) edition. Pp. viii + 644 + 29 plates. (London: Norman Rodger.) Price, 42*s.* net.

WE welcome the revised edition just published as this book has for long been recognized as the classic compendium on all that pertains to sugar from agriculture to manufacture, and this second edition enables its author to add still further from the records of his world-wide experience in all phases of the industry to the immense amount of information contained in its pages. It is from books of this type that the general public get their real information about the industry, for it is written in a style and arranged in a way which enables the general reader when tired of chemistry to turn to plant diseases, and from manufacturing to agriculture, and still continue to absorb information about an industry whose importance is only equalled by the ramifications of its component parts. Writing, however, from the point of view of India, which is, we hope, the promised land of sugar in the future, we must confess to a feeling of disappointment that this new edition has arrived at a time when the author was just starting yet another phase of his numerous activities, and had turned his attention to the Indian sugar problem. Realizing as we do the enormous labour entailed in even revising, let alone rewriting, a book of this size, it will, we fear, be many years before we can expect to see the Indian section of the book expanded and amplified with the result of the author's work and enquiries in

India, and had it been possible to delay publication for but a year to enable much of the part dealing with India to be amplified, this would have been to the manifold advantage of the book and its legion of readers. With this one regret, and that a selfish one, we must congratulate the author on a work which displays a unique grasp of all branches of the industry it deals with. [W. S.]

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Jute in Bengal.—By NIBARAN CHANDRA CHAUDHURY, M.R.A.S. New edition. (Calcutta: W. Newman & Co.)

THIS book might well be called a "handbook" as it is a compendium of useful information dealing with jute in all its stages. Statistics are tabulated in such a way as to make them readily available for reference, and for this purpose alone the book is valuable to all connected with the jute trade.

Part IV deals with the trade in jute and details the various stages through which the fibre passes *en route* from the producer to the consumer. The transition from the purchasers' marks to the pucca balers' marks might be dealt with at more length but it is difficult to describe unless the assorting can actually be seen.

The treatment of the fibre in the mill is not described, and if the author decides at any future date to bring out another edition he might consider the advisability of including a chapter dealing with the manufacture in the mill. It would add considerably to the interest and the value of the book.

The chapters devoted to the agricultural side of jute production are open to criticism. In the first place the author supplies us with information collected some 20 years ago and omits to refer to the work which has been done more recently. This is particularly unfortunate in the case of his chapter on manuring. No mention is made of potash, for example, which we now know to be the determining factor in the growth of the plant. In describing the fungus diseases which attack jute the author confines himself to a brief paragraph on *Diplodia*. No mention is made of *Rhizoctonia* which is a much more serious disease. "Chlorosis" in jute also receives no mention. It is very widespread throughout all the jute-growing

districts in Bengal and the total outturn must be very considerably affected by this disease.

Exception must be taken to the author's figures in his description of a 300-acre jute farm, and the man who is thereby induced to invest in a jute farm with the hopes of making a 40 per cent. profit might soon find himself disillusioned. [K. M.]

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The Nature of Animal Light.—By E. Newton Harvey. Lippincott's Monographs on Experimental Biology; pp. x+182, 35 figs., 1920. Price $ 2·50 nett.

Luminescence in animals, especially in insects, and the means by which it is brought about, have always excited the admiration of the layman and the wonder of the scientist, and it is not surprising that an enormous literature dealing with this subject has grown up. The present book is only a summary of recent views but will be of great value to anyone investigating this subject, for which India seems to offer so fertile a field for research. There is hardly any locality in India in which glow-worms are not available in quantity throughout the year, and an investigation of their luminescence should be not only of scientific interest but perhaps also of commercial utility, if it could be discovered how to reproduce light in this way on a practical scale. In this connection it may be remembered that the present methods of illumination are relatively wasteful, the efficiency of the tungsten incandescent lamp, vacuum type, for example, being given as 0·013, in comparison with the efficiency of the light of a fire-fly which is rated at 0·96. The fire-fly light, as it is, would be inefficient and trying for artificial illumination, as all objects illuminated by it would appear of a nearly uniform green hue. The most efficient light for human use, taking into account both colour and energy-light relationships, would be a light similar to that of the glow-worm containing no radiation beyond the visible spectrum, but differing from it by being white. The problem is a fascinating one and may be commended to the notice of any who are inclined to work on it in India. [T. B. F.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

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1. APPLIED Entomology: An Introductory Text-book of Insects in their relations to Man, by Prof. H. T. Fernald. Pp. xiv+386. (New York and London: McGraw Hill Book Co. Inc.) Price, 21*s*. net.
2. Organic Analysis, Qualitative and Quantitative, by E. de Barry Barnett and P. C. L. Thorne. Pp. xi+168. (London: University of London Press, Ltd.) Price, 7*s*. 6*d*. net.
3. The Breeding and Feeding of Farm Stock, by James Wilson. Pp. 152. (London: Methuen & Co.) Price, 6*s*. net.
4. Crops and Tillage, by J. C. Newsham. With a Preface by Lord Bledisloe. Pp. 198. (London: Methuen & Co.) Price, 6*s*.
5. Biological Chemistry, by H. E. Roaf. Pp. 232. (London: Methuen & Co.) Price, 16*s*. 6*d*.
6. Modern Milk Goats, by I. Richards. Pp. 271. (London: J. B. Lippincott Co.) Price, 12*s*. 6*d*.
7. Common Plants, by M. Skene. Pp. 271+26 plates. (London: A. Melrose, Ltd.) Price, 6*s*. net.
8. Insect Transformation, by Prof. G. H. Carpenter. Pp. xi+282 +4 plates. (London: Methuen & Co.) Price, 12*s*. 6*d*. net.
9. How to teach Agriculture: A Book of Methods in this subject, by Ashley V. Storm and Kary C. Davis. Pp. vii+434. (London: J. B. Lippincott Co.) Price, 12*s*. 6*d*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Studies in Gujarat Cottons, Part I, by Maganlal L. Patel, B. Ag. (Botanical Series, Vol. XI, No. 4.) Price, Rs. 2 or 2*s*. 6*d*.
2. The Influence of Atmospheric Conditions upon the Germination of Indian Barley, by W. Youngman, B. Sc. (Botanical Series, Vol. XI, No. 6.) Price, As. 9 or 1*s*.
3. Variations in some Characteristics of the Fat of Buffalo and Cow Milk with changes in Season and Feeding ; The Mutual Applicability of the Analytical Figures for Butter Fat and *Ghee*, by F. J. Plymen, A.C.G.I., and A. R. Padmanabha Aiyer, B.A. (Chemical Series, Vol. VI, Nos. 4 and 5.) Price, As. 12 or 1*s*. 3*d*.

Bulletin.

4. The Bundelkhand Cottons. Experiments in their Improvement by Pure Line Selection, by B. C. Burt, M.B.E., B.Sc., and Nizamuddin Haider. (Bulletin No. 123.) Price, As. 4.

Reports.

5. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Dairy Expert and the Secretary, Sugar Bureau), for the year 1920-21. Price, R. 1-8.
6. Annual Report of the Imperial Bacteriological Laboratory, Muktesar, for the year ending the 31st March, 1921. Price, As. 7.

SALE OF PEDIGREE DAIRY CATTLE.

Preliminary Notice.

On the occasion of the next meeting of the Board of Agriculture in India, an auction sale of the surplus stock of pedigree cattle of the Pusa herd will be held at Pusa on or about the 19th February, 1922.

Particulars of the cattle available for sale can be had on application to the undersigned.

G. S. Henderson,
Imperial Agriculturist.

Pusa (Bihar).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 14. THE INDIAN HOOPOE (*UPUPA EPOPS INDICA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

Except in Sind and the Western Punjab, the Indian Hoopoe is one of the most familiar of the birds which live in the Plains of India, occurring commonly, and usually abundantly as a resident in all suitable localities throughout India, Burma and Ceylon. It is a bird about the size of a mynah, fawn-coloured, the wings and tail white with very broad black bars, the legs short, the bill very long and slightly curved, and the back of the head with a conspicuous crest, which is normally kept folded so that it looks like a backward prolongation of the bill, but which is erected like an expanded fan when its owner is excited or disturbed or flies and when it first settles after flight. Specimens from South India and Ceylon run smaller than those from Northern India and have been separated under the name *Upupa ceylonensis*. Burmese specimens run larger in size, and have sometime been separated as a distinct species, *U. longirostris*, a name derived from the greater length of the bill in Burmese

examples. Besides the Indian species, the European Hoopoe (*U. epops epops*), distinguished by the presence of white between the

Head of European Hoopoe.

buff ground-colour and the black tips of the feathers of the crest on the head, is found in the Himalayas during the summer and in the winter visits the northern half of India, extending as far South as the Deccan, Chota Nagpur and Sylhet. Some Indian specimens, especially those from the North, very often show a tinge of white on the crest, and these are regarded as hybrids between the Indian and European species. In North Bihar many specimens intermediate between the Indian and European forms are to be seen. In most parts of India, however, the buff-coloured bird which is seen probing the lawn with its long bill may safely be put down as the Indian Hoopoe. A true albino with pink eyes has been recorded.

The Hoopoe is found chiefly in open country and is essentially a ground bird, only occasionally perching on trees. Its flight is slow and undulating. Like other birds which have developed a special type of bill this organ is intimately adapted to its owner's method of obtaining food, which, in the case of the Hoopoe, consists of insects and occasional worms, obtained mostly on or from under the ground, rarely on trees or in the air. The major portion of its food is obtained either by probing grassland for caterpillars living at the roots of the grasses, or by turning over leaves and rubbish for insects. It rarely picks them off plants or trees and still more rarely catches them on

the wing, although winged termites are occasionally taken in this way. The favourite haunts of this bird are avenues, especially if grass is growing in these, grasslands and lawns. It prefers slightly damp, but not wet, localities to dry ones, as its insect food is then more easily procurable. It is an interesting sight to see these birds regularly quartering a lawn, stopping every now and then to dig and probe the soil with their long beaks, the result of investigation generally yielding some insect, which is extracted and swallowed. If, however, the parent bird is collecting material to feed its young, it is often robbed by a King-crow, as we observed in our previous article on that bird.

As Mason remarks, the young birds are fed almost entirely on caterpillars (probably all cutworms), grubs of Melolonthids, and crickets, and the amount of food fed during the day to a nest of half-grown young is extraordinary. Mr. Mason watched a nest one day from 6 a.m. and in the first hour fifty-eight visits were made to the nest by the old birds, and during these visits forty-five insects were almost certainly cutworms, ten were other caterpillars and grubs (some almost certainly *Anomala* grubs) and three were crickets (one of these may have been a large beetle); during the next half-hour twenty-seven caterpillars and grubs were brought and fed to the young birds. All this food was obtained from grass lawns or under *Sissu* and mango trees. Only one insect was brought at each visit and all these insects were large ones. The same nest was watched again by Mr. Mason a week later, but the birds now seemed more wary and consequently but few of the insects fed could be identified but they appeared to be the same kinds as observed before. On the latter occasion 286 visits were paid to the nest by the parent birds between 6 a.m. and noon and about two visits per hour were made when apparently no insects were brought, so that about 274 insects were brought in and fed in six hours to the young birds, who numbered four or five at most. The food brought to the young consists practically wholly of caterpillars, beetle grubs and crickets. When bringing in food to the nest, the old bird as a rule perches near the nest to look around for danger and almost always utters a harsh

grating sound on approach to the nest and again on entering and leaving the nest.

The nesting season is in the early spring or beginning of the hot weather, and nesting takes place in any convenient hole, never at any great elevation from the ground, in trees, walls or banks. A nest has even been found on the floor of a house amongst some *bhusa* (chaff). The nest itself is a mere apology, a little hair, a few feathers, leaves or grass-stems being carelessly strewed over the floor of the hole or hollow and, when eggs are laid in a tree-hole, there is often no nest at all. These birds never remove the droppings from their nest and the stench of these is most overpowering. Four to six eggs are laid as a rule, but as many as nine are reported to have been met with occasionally. So many young are not always reared and one of these birds has been seen dropping two out of four of its young from the nest, presumably to reduce the number of mouths to feed. The egg is a very lengthened oval, pointed at one end and sometimes tending to be pointed at the other end also, not glossy, uniformly pale greyish-blue or olive-green or olive-brown or any intermediate shade, the average size being 24 by 16·5 mm. The female bird alone incubates the eggs and, especially when the eggs are near hatching, scarcely ever leaves them alone for a moment, being assiduously tended by the male bird, who brings her food continually. Mr. Inglis has seen a male bird, before the breeding season had commenced, run up to his mate and present her with an ant-lion grub. When the female bird is sitting closely in this way, she hisses like a snake if disturbed. They are very loath to leave the localities where they breed. On one occasion, to inspect a nest, the hen bird had to be pulled out of the hole and in doing so some of her tail feathers came out, but even this rather severe handling did not make her quit the place.

The young nestlings, as noted above, are fed by the parents on caterpillars and crickets and, as soon as they are able to leave the nest, they may be seen trotting after their anxious parents, making inefficient attempts at digging on their own account, but always ready to run up and have supplies thrust far down their throats by the long, curved beaks of their guardians.

It will readily be understood that a bird which feeds on insects, as does the Hoopoe, is a very useful one to the farmer. From actual examination of the stomach-contents of twenty-four birds at Pusa, the late C. W. Mason found that these had swallowed 278 insects of which the majority belonged to injurious species. A large proportion of its food also consists of cutworms and other insects living below the actual surface of the ground, so that they are fairly immune to most other enemies, and from this point of view, as a destroyer of cutworms and cockchafer grubs, the Hoopoe is most decidedly amongst the farmer's best friends and deserves every encouragement and protection. It is protected throughout the whole year, under the Wild Birds Protection Act, in Bombay, Delhi, the United Provinces, Bihar, Bengal, Assam and Burma, but in Madras in the Shevaroy Hills only. In Mysore it is not specifically protected but is presumably included in the schedule which includes all birds of bright plumage.

Both the Indian and European Hoopoes are known in Hindustani as *Hud-hud* and in Mahratti as *Sutar*. The name *Hud-hud*, as also the English name Hoopoe, are both derived from the call of these birds, a gentle "ŬK ŬK, ŬK, ŬK, ŬK," usually uttered when sitting on an exposed branch of a tree, the head being depressed until the tip of the beak almost touches the breast, the crest at the same time being laid flat down. This cry should not be confounded with the much louder deeper call of the Crow-pheasant.

Hoopoes have been kept in confinement and of course require an aviary and not a cage : the aviary should have turf laid down, as otherwise the bird's bill gets damaged whilst probing about for insects. Butler says "the best food for it consists largely of soaked ants' cocoons, supplemented by mealworms, spiders, insects of all kinds, and earthworms." They are said to get very tame in captivity.

The correct specific name of the Indian Hoopoe seems to be rather doubtful. In the third *Fauna* volume on Indian Birds, by Blanford, it is called *Upupa indica*, under which the named forms *ceylonensis*, *nigripennis* and *longirostris* are sunk, although the name *ceylonensis* has priority over *indica*, and the European Hoopoe is

separated as a distinct species under the name *U. epops.* It seems doubtful how far the Indian and European birds are really distinct and it is probably better to include them both under the name *Upupa epops*, with the names *U. epops epops* for the European race, *U. epops indica* for the North Indian race, *U. epops ceylonensis* for the South Indian and Ceylonese form, and *U. epops longirostris* for the form found in Burma.

MECHANICS OF TILLAGE IMPLEMENTS.

BY

T. A. MILLER BROWNLIE, C.E., M.I.W.E., M.I.M. & C.E.,

Agricultural Engineer to Government, Punjab.

THE evolution of the plough has left several thousands of different patterns of that implement on the markets of the world at the present day. During last century when factories were started for the manufacture of implements on a large scale, the promotors sought out those which were the most popular in certain districts, thus forming the various standard patterns.

When several implements of one class differed slightly in minor details, the ingenious mechanic produced a further type having movable parts which could be adjusted to meet the special requirements of the various purchasers. Some of these adjustable implements find great favour among many of their users, while many other users consider them an additional burden to the troubles already connected with the implements in their possession.

The reason for this diversity of opinion is obvious. The plough must first suit the soil and be adjusted to the depth, width, and shape of the furrow it is required to make; it must be capable of adjustment to suit the particular form of power employed to pull it, and that adjustment must be effected to a nicety. If the adjustments are not perfectly accomplished then the skilful ploughman will correct these defects in his handling of the implement.

Unfortunately the days of the skilful ploughman are passing away, those days when the picked men of the districts met annually in open competition, and the work of the first prizeman excelled

only in trifling detail that of the last competitor. Skill has been largely discounted by the introduction of the wheeled plough. In this implement the wheels correct the defects caused by imperfect adjustment and the same skill is not required from the ploughman. It appears, however, to have been forgotten that a bad adjustment results in increased work for the draught animals, and, therefore, to obtain the greatest efficiency, the wheeled implement should be as carefully adjusted as its simpler prototype.

A visit to several of the leading factories for the production of agricultural implements convinces one that designers of present day soil tillage implements have not studied the mechanics of the implements from the soil tillers' point of view. Many attachments provided are "selling points" only, while other absolutely essential attachments are conspicuous by their absence, such absence being compensated for by the provision of an additional mechanical device, which necessarily adds cost to the implement, and absorbs extra power. As long as the implements continue to sell, the manufacturer is content, and the farmer has to make the best of the implement procurable. Closer co-operation between the farmer and the implement designer would probably result in simplification and improvement in many implements at present in use.

It would appear that if implement makers employed more freely designers, who, in addition to their mechanical training, possessed a thorough grasp of the practical work to be done on the land by their implements, many present day models would disappear, and the tendency would be toward lower cost and greater efficiency.

The following rough analysis of the mechanics of tillage implements may be of use to the young agriculturist in overcoming some of the difficulties often experienced in operating these implements.

In the case of a simple plough working in soil of uniform density the horizontal components of the forces acting on the mouldboard and on the landside may be taken as in equilibrium: then the resultants of the vertical plane forces comprising the

normal pressures and frictional resistance may be represented as in Fig. 1 by a and b; if to the same scale a force y, representing the

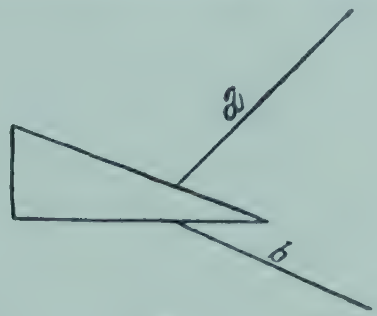


FIG. 1.

horizontal motion imparted to the implement, be drawn from g, one end of the anti-resultant R of force a and b (Fig. 2), then the

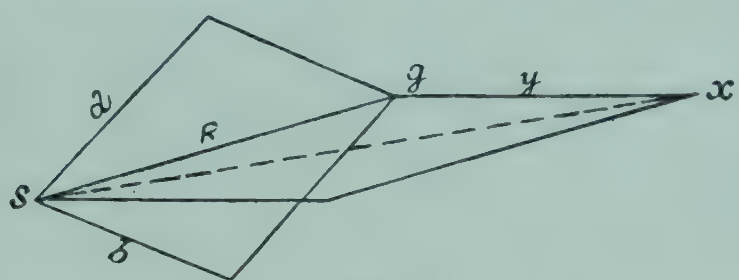


FIG. 2.

diagonal s—x of the completed parallelogram will represent, in magnitude and direction, the resultant of all forces acting on the implement.

If the total tractive force s—x (Fig. 3) be applied not in the direction s—x but in the direction s—x', then the forward motion as

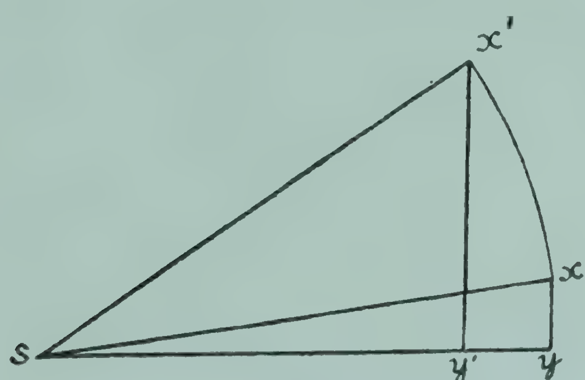


FIG. 3.

represented by s—y is reduced to s—y' and the vertical resistance as represented by y—x is increased to y'—x'. This loss of power frequently occurs in India, where, for reasons partly due to the form

of draught employed, the implement is often kept close up to the oxen, thus increasing the angle formed by the line of draught with the horizontal *x—s—y* (Fig. 3) and thereby wasting energy. The converse of this principle is exemplified in western countries where the line of draught is kept as nearly horizontal as driving facilities permit—this is known to implement makers and the implements are made in accordance with this requirement.

There is every evidence to prove that the greater part of the trouble in manipulating western implements under eastern conditions is due to the fact that these implements are primarily designed for a low draught angle and are not readily adaptable to the draught angle common in eastern countries. All forces acting on the implement, as summed in the resultant, or line of draught, must pass through the centre of resistance of the implement if the implement is to ride steadily at a uniform depth in an ideal soil of uniform density.

The centre of resistance, of a plough or any single tillage implement, is that point through which a single force must pass in order to balance or replace all forces acting on the moving implement. The centre of resistance is in the vertical line passing through the centre of gravity of the working part of the moving implement and the disturbed soil, and appears to coincide with *that* centre of gravity.

Let the point *A* (Fig. 4) represent the centre of resistance of a plough shown in the form of a triangle and *B* the draw bar or beam of the plough.

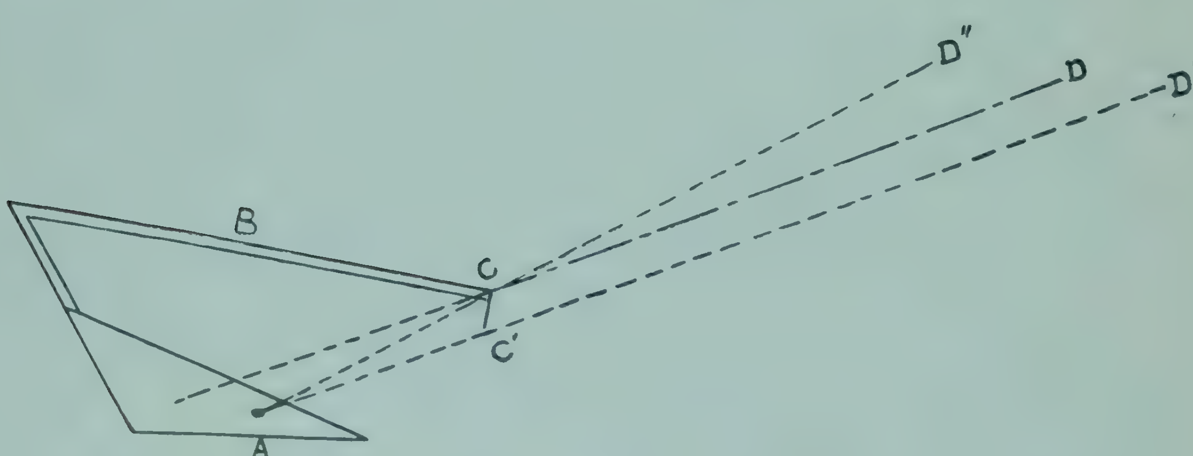


Fig.

The chain by which the implement is drawn by animal or other power is represented by the line *C—D* attached to the beam at the point *C*. Now the line *D—C* is the line of draught, and it will be observed that this line produced passes above and behind the point *A*. The result of this incorrect adjustment is that the point *A* tends to set itself in the line *D—C* produced by its leverage, which is the perpendicular distance from point *A* to *D—C* produced. With this adjustment the plough tends to dig its point into the ground, and the ploughman has to counteract this tendency by pressing on the handles.

Assuming that the angle which the line of draught makes with the horizontal is the economical angle (that is the smallest angle possible with best driving facilities), and that the height of *D* above ground level is a distance fixed by the type of draught animals employed, then, in order to correct the defect under these circumstances, the point of attachment *C* must be dropped to *C′* and the draught chain lengthened as shown by the line *C′—D′*. The line *D′—C′* produced will now pass through the centre of resistance *A* of the implement.

A less economical method of securing the same result might be necessary if the point of attachment *C* was not adjustable and could not be dropped to the position *C′*; this could be accomplished by simply shortening the draught chain to the position *C—D″* when *D″—C* produced would pass through the centre of resistance *A*, but in this case the angle formed by *D″—C* produced and the horizontal is no longer the economical angle and the draught animals have somewhat more work to do than necessary as exemplified by Fig. 3. Many plough makers attach a wheel to the beam in front of the plough or other implement ; this wheel, by pressing on the ground surface, prevents the implement " nose diving," a tendency caused by the maladjustment shown in Fig. 4. With such ploughs the ploughman need have no trouble in pressing on the handles or in adjusting the plough, but the wheel costs money, *absorbs power*, and deprives the ploughman of that skill in plough setting which at one time was of such vital necessity. If efficiency be the keynote, then this skill is *now* of paramount importance.

In the case illustrated by Fig. 5, the line of draught as shown by *D—C* produced passes in front of the centre of resistance *A* of the

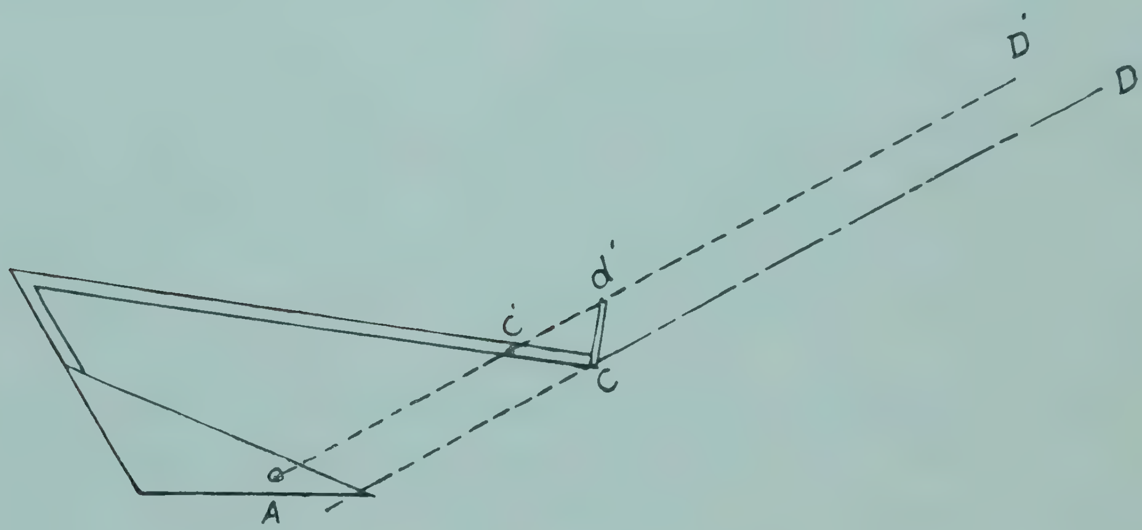


FIG. 5.

implement, the leverage being the perpendicular distance from *A* to *D—C* produced.

With this adjustment the implement will raise its point, *i.e.*, will tend to work to the surface, and the ploughman will have to exert a forward pushing force, on the handles, to counteract this tendency.

To adjust the implement correctly the draught chain would require to be attached to the beam at point *C′* or else, if a draught adjustment is fitted, the chain would be moved up to the position *d′*, the line *A—D′—d′* produced passing through the centre of resistance *A*.

When a plough is adjusted so that the line of draught passes through the centre of resistance, then the ploughman has only to correct for variations in soil density, a correction requiring only the occasional gentle touch of the skilled ploughman, man and cattle being nearly as fresh at the end of the day as when they started.

In tillage implements comprising two, three, or more tilling points, and of a type in which the points are attached to bars which are stiff in the direction of travel, such as hoes, cultivators and certain makes of harrows, etc., then the principle holds good, *viz.*, that the line of draught must pass through the centre of resistance,

if the implement is to progress with all points at a uniform depth in soil of uniform density. In implements of this class the centre of resistance is in the vertical line passing through the centre of gravity of the centres of gravity of each working part of each point and the disturbed unit of soil surrounding each point. In other words, the centre of resistance is the resultant of the centres of resistance for each point.

The ancient Egyptian and the similar present day Indian plough is provided with a long rigid draw bar or beam running the entire distance from the plough to the point of attachment at the necks of the oxen. These ploughs are locally made and generally suit the height of bullocks in the districts in which they are used. The effect of slight incorrect adjustment in a plough of this type is not so apparent as it is in a plough drawn by a flexible draught rope or chain, because *lines of stress may pass outside a rigid member without producing noticeable strain and the plough may keep its position although it and its draw bar are subjected to internal cross stresses.*

In the case of a plough or other implement drawn by a flexible draught attachment, the stress line *must pass within the flexible member* and cross stresses are an impossibility, hence the necessity for absolutely correct adjustment to secure true running of the implement.

Some modern plough makers have attempted to meet eastern requirements by attaching a rigid draw bar to a modern steel plough designed for a particular class of ploughing; it would appear impossible to produce at any central factory an implement of this type which will suit very varying heights of draught cattle in different parts of the country. In those districts where the ploughman finds difficulty in manipulating the plough, the plough is scrapped as unsuitable, the actual reason being, not because it is a bad plough, but because the line of draught does not pass through the centre of resistance, and adjustments to attain this end are not provided.

The mechanics of tillage implements is but imperfectly understood by many even of the most expert and scientific agriculturists, and naturally so, as an advanced study of kinetics

and statics is hardly part of their province. The implement makers, however, can very easily construct implements in which the line of draught will pass through the centre of resistance for average conditions, and which will have an adjustment permitting the line of draught to pass through the centre of resistance for a considerable range of conditions above and below average. A table showing positions of point of draught attachment to the "clevis," or coupling, of the implement, for different draught lengths and animal heights, would be of real benefit to the young agriculturist.

This would result in the manipulating of implements which would run level and true, without the addition of unnecessary wheels and other contraptions which are "selling points," and little better than "eye-wash" as they represent an unnecessary increase in the cost of the implement and considerable loss of energy.

It would also rapidly increase the use of modern types of implements which our agricultural authorities agree are necessary for the more efficient cultivation of the soil.

GERMINATION AND PRESERVATION OF SUGARCANE POLLEN.

BY

RAO SAHIB T. S. VENKATRAMAN, B.A.,

Government Sugarcane Expert.

Germination of sugarcane pollen.

To derive maximum benefit all pollination work involves the testing of both the pollen and the stigmas for fertility. This becomes very necessary in the case of a plant like the sugarcane, where the fertility of the sexual organs is as much an exception as the rule.

The iodine test for ascertaining the healthiness of cane pollen has been available for some time, thanks to the work of Java botanists. This, however, gives no indication as to the viability of pollen at a particular time, say, at the time of pollination, as even grains which have lost their viability stain blue with iodine. In other words, the test only indicates that the grains showing the positive reaction were viable at one time. What is required is a test for viability at the time of pollination ; and, in the experience of the writer, actual germination of the grains is the only reliable test.

Artificial culture of pollen presents difficulties of considerable magnitude owing to wide variations in the requirements of different pollens (1) as to the composition of culture media and (2) as to the optimum degrees of light and warmth for a free germination. Consequently, all attempts to germinate cane pollen in artificial culture media, made for over half a dozen years at the Cane-breeding Station, Coimbatore, proved disappointing.

Attention was, therefore, directed to growing them on live stigmas in the field, and, naturally, excellent results were obtained with sugarcane stigmas. But, as a test for viability of a particular sample of pollen, the method was found to have the following defects :—

(1) There is always the possibility of pollen from the arrow (emasculation is difficult in the cane) or other stray cane pollen (of which there is always such an abundance in the air during the cane arrowing season) getting access to the culture stigma.

(2) The germinating pollen tubes soon get lost in between the abundance of brightly coloured stigmatic hairs and are difficult to trace out.

Sowing the grains on live stigmas, other than those of sugarcane, was next tried. After an extended series of trials, comprising the testing of over 60 different species, both monocotyledons and dicotyledons, the stigmas of the following plants gave satisfactory results :—

(1) *Datura fastuosa* var. *alba*
(2) *Carica Papaya*
(3) *Hibiscus vitifolius*
(4) *Gynandropsis pentaphylla.*
(5) *Thespesia populnea.*

Ultimately, *Datura* was selected as the standard for the undermentioned reasons :—

(1) It gave the most satisfactory germination of all.

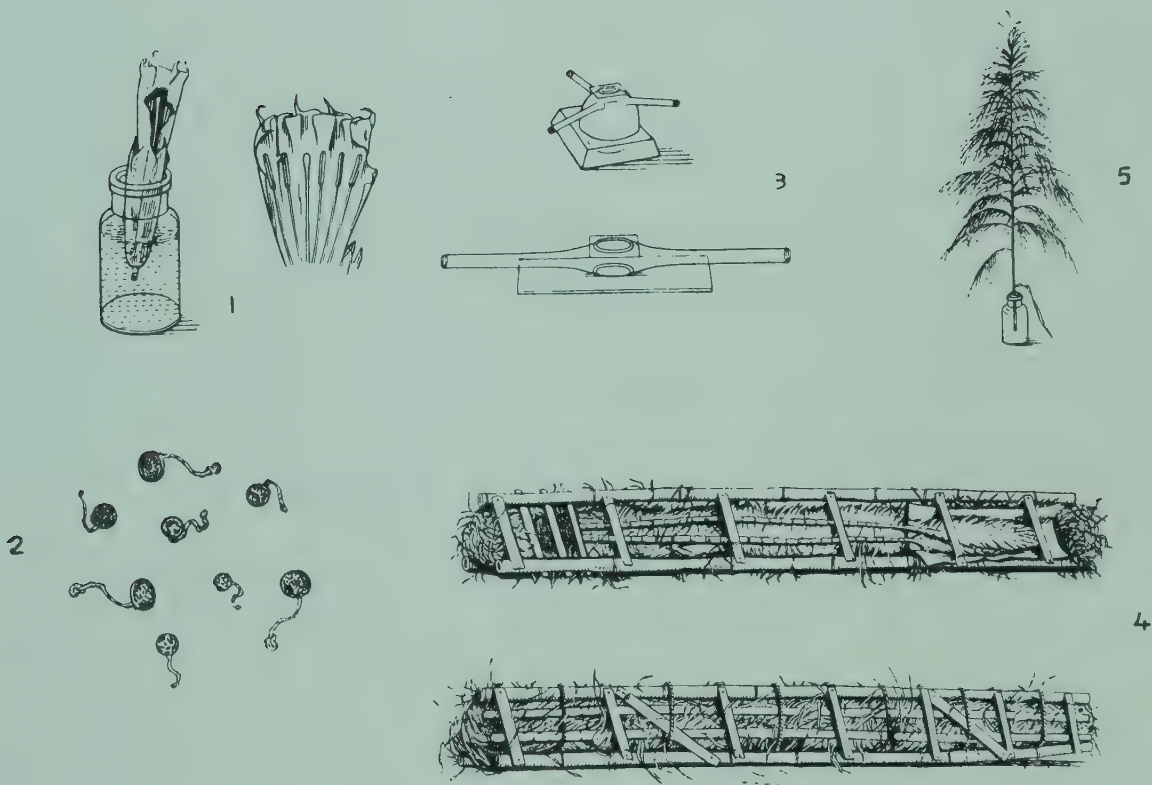
(2) The flowers are easy to emasculate and the stigmas are ready long before the anthers open.

(3) The flowers are available in quantities in the vicinity of the station during the arrowing season for canes.

(4) Stigmas remain in condition for a sufficiently long time when the bases of the flower-stalks are kept in water.

(5) *Datura* pollen could easily be distinguished from cane pollen which greatly minimizes chances of mistakes.

Details of the method of testing viability as adopted by the writer are described below.



GERMINATION AND PRESERVATION OF SUGARCANE POLLEN.

1, Flower of *Datura fastuosa* var. *alba*. *Left*, Bud with the anthers removed and ready to receive the pollen for testing ; an opening in the corolla tube shows the stigma. *Right*, Corolla tube opened out to reveal the stamens and the stigma.

2, Germinating sugarcane pollen (copied from a microphotograph).

3, Improvised chambers for preserving pollen upto three hours.

4, Bamboo crates for preserving and transporting sugarcane pollen. *Above*, Arrows in position inside the crate. *Below*, Crate packed and ready for transport.

5, An arrow from the crate kept in a bottle of water to induce anther protrusion and the subsequent liberation of pollen.

Buds of *Datura*—buds which would open the same or the next evening—are collected early in the morning and kept in bottles or tubes filled with water and with the bases of the stalks dipping under it (Plate X, fig. 1). The funnel-shaped corolla is now gently opened and the anthers which would be found quite immature pulled out with a pair of pincers. The cane pollen to be tested is now dusted on the stigmas which would be found sticky and receptive. This is now kept in a cool place, preferably the shade of the cane crop, for about an hour and a half.

For examination under the microscope, a scraping is made with a mounted needle or the sharp point of a knife and mounted in plain water. If healthy, a large number of grains would be found to have germinated (Plate X, fig. 2). Very often the nucleus can be clearly made out.

Preservation of sugarcane pollen.

Pollens vary considerably as to the relative periods during which they keep viable when out of the anther sacs. Barley pollen is reported to lose viability in about ten minutes in free air.[1] In cane pollen, viability begins to decrease in about twenty minutes in open air and often disappears altogether in about half an hour.

In cross-breeding experiments the need is frequently felt to preserve pollen for a time without its losing vitality. This generally arises from a disparity between the times of flowering of the two parents. The breeding work carried on at Coimbatore aims at raising as many crosses as possible between the thin hardy Indian canes and the thick juicy canes of the Tropics. These two classes of canes flower, however, at two different periods, the bulk of the Indian canes arrowing from fifteen to twenty days later than those of the other class. The ability to preserve cane pollen in viable condition for fairly long periods is consequently of some importance to the station.

A first series of experiments showed that, when cane pollen is kept in a moist atmosphere but with free access to open air, it

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[1] Anthony and Harlan. Germination of barley pollen. *Jour. Agri. Res.*, XVIII, No. 10, Feb. 1920.

keeps viable for as many as three hours, after which it rapidly loses vitality. Two such improvised chambers are shown in Plate X, fig. 3, the humidity being kept up with water or moistened megass placed in the excavations in the slide or the slab.

With a view to extend the period of preservation, the idea was entertained of keeping the pollen within the anthers themselves by preventing their dehiscence. It was thought that these natural receptacles might prove satisfactory for preserving vitality. Previous experience with cane anthers had shown that the dryness of the atmosphere was a factor of some importance in their opening, a dewy night retarding it by as many as two to three hours. The method described below was adopted to maintain a humid atmosphere round the anthers. Arrows which were about to protrude the anthers were cut from the field together with a fair sized stalk and placed with the base of the stalk in a bottle of water (Plate X, fig. 5). This was now placed in a narrow tin or bamboo tube and covered with a lid at the top. The lid was made sufficiently loose to allow a certain amount of exchange between the air inside the tin and that outside of it. The arrows were taken out at varying periods, and it was found that, by this method. pollen could be kept viable only from six to eight hours. Beyond this period the anthers refused to protrude when taken out.

Besides preventing dehiscence, the maintenance of the vitality of the arrow as a whole was obviously indicated. After an extended series of trials the following elaborations were made with satisfactory results :—

Arrows in which the anther protrusion is commencing at the top are selected. Very early in the morning and long before the usual time for anther protrusion, the arrows are severed from the plants together with the whole stalk and a bit of the cane at the bottom to a length of one foot. The cane portion is immediately placed in a bucket of water and a fresh cut made under the water. The bucket with the arrows is now removed to a cool place, where they are taken out and the cane portions stuck into a ball of wet clay. The arrows proper now first receive a wrapping of tissue

paper and then another of brown paper; and each individual specimen, along with the stalk and the cane portion with the ball of wet clay, is gently laid inside a bamboo crate specially prepared for the purpose (Plate X, fig. 4). These crates are made a little longer than the longest of the specimens and triangular in cross section with the sides about one foot broad. The specimens are secured with twine to the crate posts at intervals, to prevent movement of the arrows when the crates are moved as a whole. Five to six arrows are thus placed inside each crate which is then wrapped round with loose straw or cane trash and tied securely round with coir rope, when it is ready for the journey. The humidity of the air inside the crate is maintained by frequent sprinkling of water over the crates. Care has, however, to be taken to see that no portion of the arrow comes in actual contact with water, as this ruins the pollen.

When pollen is required for pollination, each specimen is separately taken out, wrappings removed, portion of the stalk with the cane portion cut off and the arrow supported in a bottle of water (Plate X, fig. 5). A fairly warm room without a blow of wind is the best place to keep the arrows in. In about half an hour the anthers would be seen to come out, dehisce and liberate the pollen very much as in the field. By testing the liberated pollen for germination it has been found that pollen could thus be kept in a viable condition for as many as eleven days from the date of cutting the arrow. The arrows are to be taken out only as they are needed for pollination and about half an hour previous. Actual tests have shown that these crates could be sent in ordinary luggage vans without spoiling the vitality of the contained pollen. The actual test carried out included a railway journey over a distance of 250 miles, lasting a whole night, and a road journey in an ordinary country cart over a distance of ten miles and lasting for a period of four hours on a fairly hot day.

Summary of results obtained.

1. Sugarcane pollen germinates freely on the live stigmas of *Datura fastuosa* var. *alba*, thus yielding a reliable test for viability.

2. Outside the anthers and in the open air, cane pollen begins to lose viability rapidly in less than half an hour. Pollination in the sugarcane should, therefore, be done as quickly as possible after the collection of pollen.

3. A method is described by which sugarcane pollen could be preserved in a viable condition for a period of eleven days.

STUDIES ON THE DECOMPOSITION OF SOME COMMON GREEN-MANURING PLANTS AT DIFFERENT STAGES OF GROWTH IN THE BLACK COTTON SOIL OF THE CENTRAL PROVINCES.*

BY

D. V. BAL, L. AG.,

Of the Department of Agriculture, Central Provinces.

Introduction.

THE application of green manures to black cotton soil is an agricultural operation frequently giving rise to considerable difficulties. By black cotton soil is understood the black soil prevailing throughout a large part of the Deccan which is generally cropped with cotton, *juar* (*Andropogon Sorghum*) or some other *kharif* (monsoon) crop. Where, however, the soil is deep enough and the rainfall sufficient, wheat and other *rabi* (winter) crops can also be grown. As a rule, in the area above indicated, irrigation facilities are not available for black cotton soil, and the soil matures its *kharif* crop on the monsoon rain and its *rabi* crop on the water stored in the soil, together with whatever rain may fall during the *rabi* season. In rice-growing areas where irrigation is possible, the application of green manure and its decomposition can to a large extent be controlled as it is possible to maintain the moisture conditions of the soil at any desired state, but such facilities being generally absent in the black cotton soil tract, green-manuring in this tract is not an operation always attended with success. Black cotton soil is, however, generally so deficient in

* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

nitrogen and organic matter that green-manuring is strongly indicated, and it was considered that more detailed information on the factors governing its successful practice was required.

Experiments on the utility of green manures for *rabi* crops on the black cotton soil, especially wheat, have been carried out on the experimental farms at Nagpur and Hoshangabad since 1904 and 1909 respectively. The results of these experiments have been recorded by Allan[1] in his paper on "Green-manuring in the Central Provinces." He points out the importance of the early inversion of the green-manuring material and the intimate relationship between the rainfall subsequent to ploughing in the green manure and the yield of the following *rabi* crop. He also expressed the opinion that a minimum rainfall of 35 inches was necessary for successful green-manuring for *rabi* crops.

As regards previous work bearing on the problem dealt with in this paper, the papers by Hutchinson and Milligan[2] and by Joshi[3] may be mentioned. Hutchinson and Milligan carried out laboratory experiments on the decomposition of sann-hemp at various stages of growth and under different conditions in Pusa soil—a calcareous Gangetic alluvium of a loamy character. They considered the quantitative transformation of nitrogen alone. Joshi's work was on the comparative rate of nitrification of different green-manuring plants and different parts of the plants used as green manures in Pusa soil. He found from his experiments that the more tender and hence more easily decomposable the tissue, the slower the nitrification. This is rather contrary to general expectation; in fact, a heavy growth, leafy habit and soft non-fibrous character have been taken as indicating a plant easy of decomposition resulting in a greater nitrate accumulation. (Allan).[4] Experience in these provinces indicates that the earlier the green plants are ploughed in, the better is the succeeding *rabi* crop, but this is not quite in agreement with what

[1] *Agri. Jour. India*, X, p. 380.

[2] *Agri. Res. Inst. Pusa Bull.* 40, 1914.

[3] *Agri. Jour. India*, Special Ind. Science Congress No., 1919.

[4] *Loc. cit.*

might be expected from the results obtained in laboratory experiments with Pusa soil (Joshi)[1] where a more tender plant produced a smaller accumulation of nitrate than a woody plant. The relationship between the nature of the growth or maturity of a plant and its susceptibility to decomposition in black cotton soil has, therefore, been made subject to experiment, and this paper records the results obtained from a detailed study of the following factors connected with the process of green-manuring :—

(1) The rate of growth of plants used as green manures.

(2) The composition of the plants at various stages of growth.

(3) The rate of decomposition of the nitrogenous and carbonaceous constituents of the plants at various stages of growth and of different parts of plants, *i.e.*, leaves and stems.

(4) The effect of varying proportions of stems on the decomposition of leaves.

Experimental.

Seeds of sann-hemp (*Crotalaria juncea*) and *dhaincha* (*Sesbania aculeata*) were sown separately in duplicate pots containing black cotton soil at the beginning of the monsoon. At the end of two, four, six and twelve weeks, plants from duplicate pots of each variety were cut and used for the experiments on decomposition. With the exception of the experiments on the 12 weeks' growth of sann-hemp which were carried out in the season of 1920, all the others were carried out in 1919. The soil used for both the laboratory experiments and the pot cultures was from the Nagpur farm, and a description of its physical nature, etc., has been given by the writer[2] in one of his previous publications. It is a typical black cotton soil.

Soil representing 400 grm. of dry soil was mixed thoroughly with the required quantity of freshly cut green manure to be tested,

[1] *Loc. cit.*

[2] *Agri. Jour. India*, Special Ind. Science Congress No., 1919.

precautions being taken to secure cut pieces of the green stuff of a uniform length of half an inch. The optimum percentage of water favouring decomposition has been found to be 30 per cent., and in order to allow for the moisture originally contained in the soil and in the green manure all of the 30 per cent. water was not added at once, but the deficiency was made up after the moisture determinations in the green manures had been made. A fixed quantity of nitrogen per 100 grm. of soil was not taken, but the amount of nitrogen added in the form of green manure was calculated afterwards when the nitrogen determinations had been carried out. Samples for moisture, ash and organic matter determinations were always taken immediately after the plants from each individual lot had been cut and while starting the nitrification and CO_2 production experiments. The remaining portions of the samples were thoroughly dried in an air oven at 100° C., ground in the sampling mill and kept in stoppered bottles for the estimations of nitrogen, carbon, etc.

Had this procedure not been adopted a good deal of time, about 10 hours at least, would have been required for the determinations of moisture and nitrogen in order to take a fixed quantity of nitrogen per 100 grm. of the soil, thus involving a great interval between the time of cutting up the green manure and mixing it with the soil, with the consequent loss of moisture. As experience of Hutchinson and Milligan[1] with sann-hemp and of Whiting and Shoonover[2] with green and cured tops of clover shows, this point of immediately mixing the cut green stuff with the soil is of very great importance.

Nitrites and nitrates were estimated by the Gries Ilosvay method and the phenol-disulphonic acid method respectively, and the amount of ammonia was estimated wherever necessary by the usual magnesia method. A detailed description of the process of these estimations has already been given.[3]

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[1] *Loc. cit.*

[2] *Soil Science*, IX, pp. 137–149.

[3] *Agri. Jour. India*, Special Ind. Science Congress No., 1919, p. 417.

In order to measure the rate of decomposition of the carbonaceous matter of the various samples, 100 or 200 grm. lots of the soil were taken, mixed with the green manure, and water added as described previously in the nitrification experiments. The difference of moisture in this case, however, was made up immediately after the first CO_2 estimation, the small quantity of water required being added by means of a graduated pippette and mixed with the soil by shaking. Erlenmeyer flasks of 500 c.c. capacity, fitted with rubber corks having two delivery tubes, one going right up to the bottom while the other one remaining nearly half the way inside the flask, were employed to hold the soil. The two ends of the delivery tubes were plugged with cotton wool in a fairly loose manner. The flasks were connected with aspirators and every day 2 litres of air freed from CO_2 was passed over the soil and into Petencoffer tubes containing standard $\frac{N}{10}$ barium hydroxide solution and phenol-phthalein. Titrations were done with $\frac{N}{10}$ hydrochloric acid. A control experiment taking the same quantity of soil and water but no green manure was also made with each series of determinations.

The relative heights and weights of the green-manuring plants of varying maturity are given in Table I and a detailed chemical

TABLE I

Showing average height in inches and average weight in grm. per plant of the respective green manures.

Green manure	2 weeks old		4 weeks old		6 weeks old		12 weeks old	
	Average height	Average weight	Average height	Average weight	Average height	Average weight	Average height	Average weight
Sann-hemp ..	15	..	24	4·05	36	7·86	50	7·0
Dhaincha ..	10	..	14	1·17	16	1·50	..	..

TABLE II

Showing the relative chemical composition of the various green-manuring plants in terms of percentages calculated on fresh green samples.

Description of the manure	Mois-ture	Ether ex-tract	(a) Pro-tein	(b) Fibre	Ash & sand	(c) Carbo-hydrates	N	(d) C	(e) Organic matter
1	2	3	4	5	6	7	8	9	10
Sann-hemp (2 weeks growth) ..	88·5	0·16	2·74	1·81	1·60	5·19	0·44	5·11	9·90
Dhaincha (2 weeks growth) ..	89·4	0·19	3·15	0·92	1·57	4·77	0·50	4·48	9·03
Sann-hemp (4 weeks growth) ..	82·5	0·27	2·79	5·69	1·80	6·95	0·45	7·84	15·70
Dhaincha (4 weeks growth) ..	82·6	0·47	3·18	4·68	1·62	7·46	0·51	7·95	15·78
Sann-hemp (6 weeks growth) ..	74·5	0·68	1·99	10·55	2·62	9·66	0·32	11·15	22·88
Dhaincha (6 weeks growth) ..	79·0	0·72	3·13	4·69	2·24	10·22	0·50	9·35	18·76
Sann-hemp (12 weeks growth) ..	65·0	0·47	2·01	16·56	1·90	14·06	0·32	15·86	33·10
Stems alone from sann-hemp (12 weeks growth) ..	64·0	0·38	1·44	19·30	1·33	13·55	0·23	16·13	34·67
Leaves alone from sann-hemp (12 weeks growth) ..	69·0	0·90	4·42	6·41	2·90	16·37	0·71	13·46	28·10

(a) The factor 6·25 was used for calculating the protein percentage from nitrogen.
(b) Determined by digestion with acid and alkali of 1·25 per cent. strength.
(c) By difference.
(d) By combustion.
(e) Determined by subtracting the total of columns 2 and 6 from 100.

analysis of the various samples is embodied in Table II. The figures in Table II show :—

(1) The percentage of moisture decreases as the green-manuring plants advance in age. This decrease is not, however, so great in the case of *dhaincha* as in the case of sann-hemp.

(2) The percentages of carbon, carbohydrates and fibre increase with the age of the plants.

(3) There is not an appreciable change in the percentage of nitrogen due to the increased growth of plants.

The comparative distribution of the total nitrogen in leaves and stems will be found in Table III and the relative proportion of leaves and stems in green sann-hemp 6 and 12 weeks old in Table IV.

TABLE III

Showing the distribution of the nitrogen expressed as percentage of the total nitrogen contained in sann-hemp.

	Nitrogen in leaves	Nitrogen in stems	
Sann-hemp (6 weeks growth)	55·9	44·1	11·4 top 13·7 middle 19·0 bottom
Sann-hemp (12 weeks growth)	52·1	47·9	

TABLE IV

Showing the proportion of leaves to stems in the samples of green sann-hemp in terms of percentages.

	Leaves	Stems	
Sann-hemp (6 weeks growth)	41·1	58·9	12·2 top 18·1 middle 28·6 bottom
Sann-hemp (12 weeks growth)	26·2	73·8	

These figures show that the relation between the percentages of nitrogen in leaves and in stems in the green manure under experiment varies but slightly with change in growth but that the proportion of leaves to stems is greatly reduced as the plants age.

The comparative rates of decomposition of the nitrogenous constituents as measured by the amounts of nitrites and nitrates formed in the case of sann-hemp and *dhaincha* are given in Table VI. It is seen from this table that the total percentage of nitrogen nitrified in the case of sann-hemp begins to fall as the green manure advances in age. Hutchinson and Milligan in their experiments with Pusa soil found that the maximum percentage of nitrogen nitrified after a period of 8 weeks in the case of 4, 6 and 10 weeks growth of sann-hemp was 67·8, 50 and 34·5 per cent. respectively, while the figures for black cotton soil are 57·3, 36·1 and 16·0 for 4, 6 and 12 weeks growth respectively. Their results are therefore of the same order as those described in the present paper.

TABLE V

Showing percentage nitrogen nitrified (including nitrites and nitrates) in leaves, stems, etc.

	6 WEEKS OLD SANN-HEMP				12 WEEKS OLD SANN-HEMP		
	200 grm. soil + 10 grm. leaves	200 grm. soil + 8 grm. top stems	200 grm. soil + 10 grm. middle stems	200 grm. soil + 10 grm. bottom stems	400 grm. soil + 20 grm. leaves	400 grm. soil + 20 grm. whole stems	400 grm. soil + 20 grm. leaves +20 grm. whole stems
After 2 weeks ..	..	..	..	..	15·03	nil	8·55
„ 4 „ ..	36·88	44·66	21·97	nil	19·92	nil	16·80
„ 6 „ ..	..	..	..	..	23·24	6·66	17·51
„ 8 „ ..	39·37	44·66	21·97	nil	..	..	..
„ 10 „ ..	..	..	..	..	27·20	11·10	24·60
Mg. of nitrogen added per 100 grm. soil ..	26·04	14·34	14·56	12·74	35·35	11·55	46·90

TABLE VI

Showing the total percentage nitrogen nitrified including nitrites and nitrates.

	Sann-hemp				Dhaincha		
	400 grm. soil + 21 grm. green manure (2weeks growth)	400 grm. soil + 20 grm. green manure (4 weeks growth)	400 grm. soil + 20 grm. green manure (6 weeks growth)	400 grm. soil + 20 grm. green manure (12 weeks growth)	400 grm. soil + 21 grm. green manure (2 weeks growth)	400 grm. soil + 20 grm. green manure (4 weeks growth)	400 grm. soil + 20 grm. green manure (6 weeks growth)
	Percentage nitrogen nitrified						
After 2 weeks ..	56·26	36·73	24·09	1·06	43·47	45·26	46·12
„ 4 „ ..	69·60	51·58	24·09	11·96	60·41	50·33	51·24
„ 6 „ ..	78·00	51·58	32·12	13·02	62·83	55·36	61·50
„ 8 „ ..	72·39	57·31	36·14	..	60·41	62·90	..
„ 10 „ ..	..	..	..	16·00	..	..	..
Mg. of nitrogen added *per* 100 grm. soil ..	23·00	22·35	15·95	16·05	26·50	25·45	25·00

The following factors require consideration before attempting to correlate the gradual fall in the percentage of nitrifiable nitrogen with the advance in age of the green crop. The first consideration is the relative proportion of leaves to stems, the second, the rate of decomposition of the leaves and stems separately, and the third, the effect of varying proportions of stems on the decomposition of leaves. Results of the experiments that were made to determine factors two and three are tabulated in Table V, while Table IV, giving the relative proportion of leaves to stems, has already been referred to. With these data it is proposed now to discuss the various results.

Figures given in Table V show clearly that the nitrogen in leaves is more easily nitrifiable than that in whole stems. It is also clear that the top portions of the stems are more nitrifiable than the bottom portions.

In the case of sann-hemp 6 weeks old the percentage of nitrogen nitrified after 8 weeks is 36 per cent. (Table VI.) This represents the total oxidation of nitrogen in both leaves and various parts of stems taken together as they are present normally in a fresh sample. Now, if we calculate from the figures given in Tables III and V, the total percentage of nitrogen that should be nitrified in 8 weeks if the various parts of the plant were mixed separately with the soil, the following figures will be obtained :—

55·9 per cent. of the total nitrogen is in the leaf and 39·37 is the maximum percentage of this nitrogen nitrifiable in 8 weeks. Therefore $\frac{55 \cdot 9 \times 39 \cdot 37}{100} = 22 \cdot 00$ represents the nitrogen in the leaf which could be nitrified if 100 parts of nitrogen as contained in the whole plant were added. Similarly the top, middle and bottom parts of stems give $\frac{11 \cdot 4 \times 44 \cdot 66}{100} = 5 \cdot 09$ plus $\frac{13 \cdot 7 \times 21 \cdot 97}{100} = 2 \cdot 01$ plus $\frac{19 \times 0}{100} = 0$ of nitrogen nitrified.

The sum of these is 29·10 representing the maximum nitrifiability of 100 parts of nitrogen in the plant as a whole if all the parts are added to the soil separately. As already stated, a direct determination shows that 36 per cent. of the nitrogen in the whole plant is nitrifiable in 8 weeks.

This shows that there is no decrease in the maximum percentage of nitrogen nitrified in a sample of 6 weeks old sann-hemp when it is added as a mixture of leaves and stems to the soil, compared with the results obtained when the individual portions are added separately.

In the case of 12 weeks old sann-hemp the maximum percentage of nitrogen nitrified after a period of 10 weeks is 16·1, and if calculated on the basis of nitrification of the individual parts—leaves and stems—as in the previous case, it should be as follows :—

Leaves $\frac{52 \cdot 1 \times 27 \cdot 2}{100} = 14 \cdot 20$

Stems $\frac{47 \cdot 9 \times 11 \cdot 1}{100} = 5 \cdot 32$

Total 19·52 per cent.

Within the limits of experimental error this experiment also indicates that the stems of sann-hemp do not to any appreciable extent inhibit the nitrification of the leaves as, if this were the case, the maximum nitrification of leaves and stems separately would be appreciably higher than when the whole plant is added to the soil. Further evidence on this point was obtained by reducing the natural proportion of leaves to stems (*viz.*, 73·8 to 26·3 per cent.) to 50 per cent. of each. This was done by adding leaves and stems in equal quantities to the soil, the quantities taken being 20 grm. each of leaves and stems, to 400 grm. of soil. At the same time 20 grm. of leaves and 20 grm. of stems were added separately each to 400 grm. of soil.

The actual amount of nitrogen in 5 grm. of leaves and stems separately is 35·35 and 11·55 mg. making a total of 46·9. This quantity is that added to 100 grm. of soil. The maximum percentage of nitrogen nitrified was 27·2 in the case of leaves and 11·1 in the case of stems. Therefore the total maximum nitrifiable nitrogen added to 100 grm. of soil, when both were added together, is $\frac{35 \cdot 35 \times 27 \cdot 2}{100} + \frac{11 \cdot 55 \times 11 \cdot 1}{100} = 10 \cdot 9$ mg. 46·9 mg. of nitrogen in the mixture has, therefore, 10·9 mg. of nitrifible nitrogen or $\frac{10 \cdot 9 \times 100}{46 \cdot 9}$ or 23·24 per cent. This is the calculated figure. The actual experimental figure as in Table V is 24·6, showing that within the limits of experimental error the effect of the stem on the nitrification of nitrogen in the leaves is unappreciable. The nitrogen in the leaves or the stems appears to nitrify to the same extent in black cotton soil when the stems and leaves are mixed as when they are kept separate.

These results do not support the statement made by Joshi[1] in his paper that " it is the leaves that are nitrified in the soil, the stems and roots, if anything, inhibiting the nitrate formation or destroying the nitrates formed from leaves." If the presence of stems resulted in denitrification of the nitrates formed from leaves, then nitrites would at some stage probably be found

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[1] *Loc. cit.*

to accumulate. It may, however, be mentioned here that no extraordinary accumulation of nitrites was observed in any of these experiments in spite of the increasing amounts of stems in some of the samples.

The diminution of nitrifiable nitrogen in sann-hemp of advanced age does not therefore appear to be due to any deleterious influence of the stems upon the nitrification of leaf nitrogen. Any of the following causes may be responsible wholly or in part for reduced nitrification in the matured plant:—

(1) It is known that the fibre is more resistant to the action of micro-organisms than the other constituents of the plant, and any nitrogen contained in it would therefore be in a comparatively non-available form. Chemical determinations made in connection with this point showed that in the green sann-hemp of 12 weeks growth and in the case of stems alone from the same sample, out of the total nitrogen present about 11 and 18 per cent., respectively, was contained in the fibre. Increasing amounts of fibre in the sann-hemp as it advances in age would therefore indicate increasing amounts of nitrogen becoming more and more resistant to decomposition, thus accounting, partly at any rate, for the reduction in nitrification in the case of green manures of advanced age.

(2) It is possible that the increasing amounts of carbohydrates (Table II) in the green sann-hemp, as it advances in age, exert some deleterious influence on the nitrifiability of the nitrogenous constituents or the carbohydrates may stimulate nitrate reduction. Though it is true that this is possible in the case of solutions, it is doubtful if the same holds good in the case of soil, particularly when we consider the relatively small amount of green stuff that is added in the usual practice of green-manuring. No definite opinion on this point can however be formed at present in the case of black cotton soil but, as far as nitrate reduction is concerned, no extraordinary accumulation of nitrites was observed in any of these experiments in spite of the large amounts of carbohydrates present in some of the material under experiment.

(3) A regular decrease in the moisture content of the green manure (Table II) as it advances in age may be partly responsible

for the decrease in nitrification in the case of 6 and 12 weeks old sann-hemp. It has already been pointed out that artificial drying retards the nitrification process as seen from experiments of Hutchinson and Milligan[1] and those of A. L. Whiting and W. R. Schoonover.[2] The explanatory hypothesis given by Whiting and Schoonover in their paper is reproduced below as it seems to throw some light on this question :—

"The change which dehydration (curing) brought about in the rate of the initial decomposition (of clover) appears to be of a physical nature only. An explanatory hypothesis is that dehydration resulted in a hardening and shrivelling of tissues which interferes with the re-entrance of water and consequently delays the decomposition because the bacteria must await the softening of the tissues before they are able to start their work, while with the green no such delay occurs as the cells are already hydrated."

In the case of completely dried plants there is a maximum amount of dehydration which would exert a maximum deterrent effect, while in the case of green sann-hemp advanced in age this effect may be only partial. From the figures given in Table VII it will be seen that, in spite of the increasing percentage of carbohydrates with the advance in age of the green sann-hemp, there is a gradual reduction in the percentage of carbonaceous material decomposed, and this supports the view that, because of the altered physical condition of the various plant constituents in mature sann-hemp, decomposition by micro-organisms is not easily carried out.

In the absence of any other direct evidence it is not possible to say which of the two factors mentioned above, the formation of resistant nitrogenous substances or the hardening of the plant tissues by partial drying, is more responsible for the reduction in nitrification of mature sann-hemp.

From the results given in Tables VI and VII, it is seen that the more succulent the sann-hemp plants are, as determined from the

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[1] *Loc. cit.*

[2] *Loc. cit.*

high percentages of moisture, low percentages of fibre and shortness of period of growth, the more easily are their various constituents decomposed.

In the case of *dhaincha* there is practically no decrease in the rate of nitrification as the plants advance in growth. This can be explained if we observe the relative growth and height of the sann-hemp and *dhaincha* plants given in Table I and their compositions as given in Table II. It is seen that there was not any marked growth of the *dhaincha* plants and at the same time the range of variation in the percentages of fibre and moisture in the various stages of growth was not very great when compared with similar figures for sann-hemp. The opinion was given previously that a gradual decrease in the moisture content and an increasing proportion of non-available nitrogen due to the rise in fibre content are largely responsible for the decrease in nitrification of sann-hemp plants as they advance in growth. This is further supported by the results obtained from the experiments with *dhaincha*. The fact that *dhaincha* is a slow grower in early stages as compared with sann-hemp under conditions prevailing with black cotton soil is well known and is also mentioned by Allan[1] in his paper on "Green-manuring in Central Provinces." *Dhaincha* has, however, certain advantages in resisting excessive moisture, and hence it is used as a green-manuring crop in some paddy-growing tracts and in the case of other crops where a sufficient time can be allowed for its full growth before it is turned into the soil as a green manure.

Having dealt with the decomposition of the nitrogenous constituents of plants used as green manure, we shall now consider the decomposition of the carbon constituents.

Determinations of CO_2 were made daily until the amount of CO_2 produced decreased considerably below that given off on the first day. The results of decomposition of sann-hemp as measured by the rate of CO_2 production per day are given in Table VII.

These results show a regular fall in the percentage of carbon oxidized as the age of the sann-hemp advances and are therefore

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[1] *Loc. cit.*

parallel to those of nitrification but the duration of these experiments was from 15 to 20 days only. Experiments with 6 weeks old sann-hemp could not be completed but the results are given so far as available.

Potter and Snyder[1], in their experiments on the decomposition of carbon in green and dried plants, carried on their determinations for from 53 to 216 days, and found there was not any very great difference in the total percentage of carbon oxidized whether the green manure was added green or dry. Recent work by White[2] also shows only 3·3 per cent. more total organic matter oxidized when green manure is added fresh than when added dry, the determinations being continued for 9 months. The decrease in the rate of oxidation of carbon with the increase of maturity of the sann-hemp, as found by the author, may therefore be in the earlier stages of decomposition only.

From the experiments under consideration it is seen that during a period of nearly 3 weeks the decomposition of the leaves of mature sann-hemp produces twice as much carbon dioxide as that of the stems, calculated on equal weights of carbon in the leaves and stems separately. This indicates that when the plant is 12 weeks old the leaf carbon is more readily oxidized than that in the stems.

The presence of stems does not appear to affect the oxidation of leaf carbon as the following figures show :—

5 grm. leaves alone per 100 grm. soil	gave off		183·1 mg. C as CO_2
5 grm. stems	,,	,,	128·2 mg. C as CO_2
	Total	..	311·3

A mixed sample of 5 grm. leaves plus 5 grm. stems per 100 grm. soil gave off 298·1 mg. C as CO_2 or 20·16 per cent. Calculations made from the individual results of leaves and stems given above show that 21·06 per cent. of the carbon should have been oxidized,

[1] *Jour. Agri. Research*, XI, pp. 677–698.
[2] *Jour. Agri. Research*, XIII, pp. 171–197.

a difference which within the limits of experimental error cannot be said to indicate any effect of stems on the oxidation of leaf carbon.

Similar results were obtained in the case of a normal sample of green manure 12 weeks old containing 26·2 per cent. leaves and 73·8 per cent. stems. The maximum percentage of carbon that should be oxidized in a normal sample of 12 weeks old sann-hemp, if calculated from the individual figures for leaves and stems, comes to 18 per cent. whereas the percentage actually found is 21·2 per cent. As in the case of nitrogen oxidation, also the carbon in the leaves or the stems appears to oxidize to the same extent when the stems and leaves are mixed as when they are kept separate.

The rate of oxidation of carbon in *dhaincha* is given in Table VIII. These results show that there is a similar decrease in the oxidation of carbon in *dhaincha* as in the case of sann-hemp. The results for the 6 weeks old plant cannot be taken as entirely comparable as the experiments could not be carried through completely.

While these results throw some light on the quantitative rate of decomposition of the nitrogenous and carbonaceous constituents of the green-manuring plants, they also support the field experiments carried out in these provinces and summarized by Allan[1], showing that sann-hemp of about 6 weeks growth is in a condition to undergo rapid decomposition and so become of value to the succeeding *rabi* crop. The moisture factor must, however, not be overlooked.

In conclusion, I wish to express my best thanks to Mr. A.R.P. Aiyer, Offg. Agricultural Chemist, for providing some of the chemical analyses quoted in this paper.

Summary.

1. Observations on the rate of growth of sann-hemp (*Crotalaria juncea*) and *dhaincha* (*Sesbania aculeata*) in black cotton soil show that the latter is a comparatively slow grower in its initial stages.

[1] *Loc. cit.*

2. It is seen that as the green plants advance in age the proportion of leaf to stem decreases and the percentages of dry matter and fibre increase.

3. It is seen that the earlier sann-hemp is used as green manure the more rapid is the decomposition of its carbonaceous and nitrogenous constituents. With *dhaincha*, however, there was no marked decrease in the rate of nitrification of the comparatively older plants, though there was a certain amount of decrease in the decomposition of carbonaceous constituents.

4. Nitrogen in the leaves of sann-hemp is more easily nitrified than that in stems.

5. Stems of sann-hemp do not appear to have any retarding effect on the decomposition of *sann* leaves in black cotton soil.

6. The slowness of decomposition in full-grown green *sann* plants is not due to any effect of the increasing proportion of stems on leaves. It may be due to the change in composition of the plants and such alterations which take place in the physical condition of the plant tissues owing to a large reduction in the water content. Plant tissues partially dried owing to advance in age require time to absorb water from the soil and thus become susceptible to attack by soil micro-organisms.

TABLE

Showing the amount of CO_2 evolved on successive days

	Mg. CO_2 evolved per 100 grm. of soil									
2 weeks growth	16·06	31·13	39·16	48·73	46·97	29·81	14·52	10·78	6·82	6·93
4 weeks growth	16·94	28·38	32·56	93·06	47·96	40·26	30·80	17·60	9·90	9·02
6 weeks growth	17·16	28·82	38·50	55·22	58·08	57·86	88·88	47·30	38·94	51·92
12 weeks growth	19·36	30·14	40·26	35·20	36·30	38·28	40·26	45·10	40·26	41·80
Leaves alone from 12 weeks growth	43·12	56·98	68·20	72·60	75·24	73·04	58·96	44·22	34·54	33·00
Stems alone from 12 weeks growth	14·96	18·04	17·16	18·26	25·74	29·48	48·18	48·40	46·42	37·40
Leaves and stems from 12 weeks growth in equal proportions ..	38·06	59·62	62·92	73·04	81·62	87·34	86·68	90·20	88·66	79·64

TABLE

Showing the amount of CO_2 evolved on successive days and the

	Mg. CO_2 evolved per 100 grm. of soil							
2 weeks growth, 100 grm. soil, 4 grm. green manure	17·71	36·74	38·83	41·14	35·53	23·10	10·56	7·92
4 weeks growth, 100 grm. soil, 4 grm. green manure	16·50	32·78	42·46	92·40	40·48	26·18	22·00	14·30
6 weeks growth, 100 grm. soil, 5 grm. green manure	17·16	30·36	40·04	47·30	44·88	44·66	75·02	36·30

VII

and the percentage of carbon oxidized in sann-hemp.

each successive day										Total amount of CO_2 given off in mg.		Total amount of carbon added as green manure in mg.	Total percentage carbon oxidized
										As CO_2	As C		
15·73	6·82	5·39	4·40	3·63	3·85	4·84	..	..	..	295·57	80·8	204·4	39·60
7·70	7·92	11·88	6·88	3·74	3·08	..	..	..	..	367·62	100·2	313·6	31·96
..	..	..	..	..	..	..	..	..	..	482·68	131·6	557·5	23·60
41·80	28·16	27·28	35·42	39·38	36·96	18·70	11·22	11·44	..	617·32	168·4	793·0	21·24
24·86	14·96	12·10	11·44	10·12	12·76	10·34	6·82	8·14	..	671·44	183·1	673·0	27·20
31·90	22·66	22·00	19·80	18·92	21·56	12·54	7·92	8·58	..	469·92	128·2	806·5	15·90
66·88	48·18	41·58	32·56	29·48	34·76	27·94	22·88	25·96	15·18	1093·18	298·1	1479·0	20·16

VIII

percentage of carbon oxidized in dhaincha.

each successive day									Total amount of CO_2 given off in mg.		Total amount of carbon added as green manure in mg.	Total percentage carbon oxidized
									As CO_2	As C		
6·27	6·05	15·40	5·08	4·18	3·85	2·86	3·63	5·61	264·46	72·20	179·20	40·30
8·36	8·80	8·36	8·80	14·08	8·14	3·96	3·30	..	350·90	95·70	318·00	30·10
31·24	54·12	..	..	..	..	..	..	..	421·08	115·00[1]	467·50	24·60

A DISEASED CONDITION OF RICE.

BY

F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.,
Second Imperial Mycologist.

A RECENT publication[1] from the United States describes a diseased condition of irrigated rice which resembles that which has sometimes been observed in India in specimens submitted for mycological examination. The disease is named "straighthead" of rice and is stated to be one of the most destructive diseases of irrigated rice in the southern part of the United States. The chief symptom, from which the name is derived, is that the riceheads, or panicles, are nearly sterile and remain erect when mature. In severe cases plants even fail to head. All parts of the plants, however, may be affected. The leaves are said to be greener and somewhat stiffer than normal, and diseased plants remain green long after normal plants are mature and dead. There is an abundance of large roots, but few small roots and root hairs are developed.

The disease is said to be caused by certain unfavourable soil conditions, all attempts to find a parasitic organism having failed. The unfavourable condition of the soil is attributed to decaying organic matter, which produces a condition that allows an excess of water to be taken into the soil. The air is thus pressed out of the soil and, in the resulting lack of aeration, the root system fails to develop normally, disturbing the nutrition of the plant and causing the formation of empty grains. Hence the plants remain sterile and straighthead is the result. Straighthead is therefore attributed

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[1] Straighthead of Rice and its Control. *U. S. A. Dept. Agri. Farmers' Bull.* 1212.

to lack of aeration in the soil and is said to be prevented by a proper system of irrigation and drainage, recommendations which have recently been advanced as a cure for " wilt " of indigo in Bihar.

The explanation of straighthead which is advanced in the paper under review is a purely physical one. If we admit that lack of soil aeration is the cause of straighthead, it is by no means improbable that the deficit of oxygen is due to more complex causes than are suggested. The presence of decaying organic matter would at least suggest that bacterial activity may result in the production of toxins, and that the benefits of aeration are due rather to the oxidation of these toxins than to the direct supply of oxygen to the plant. In paddy growing in swamp soils it has been shown that the action of an algal growth on the surface, combined with a slow downward percolation of water, results ultimately in an increase of root aeration. The downward percolation of water is a necessary condition for the health of the crop. The fact that in some parts of India large quantities of green leaf are puddled into the soil is in contradiction to the view that decaying organic matter produces a soil condition injurious to paddy. However, it cannot be denied that a condition of paddy similar to that described as straighthead is by no means scarce in India.

In India a considerable proportion of the specimens showing this condition come from the districts of Raipur and Bilaspur in the Central Provinces. A small percentage of these specimens are parasitized by *Sclerotium Oryzæ* Catt. but in the remainder no causal organism has been found. In other cases, from the Punjab, Burma and Assam, paddy showing these symptoms has been found infected with a fungal parasite, probably a species of *Cephalosporium*. The part which this fungus may play in causing paddy disease is at present obscure but, allowing for a proportion of damage due to these parasites, there remains in specimens from the above areas and from Bihar and Orissa and Kashmir a considerable amount of disease for which at present a satisfactory explanation, on a parasitic basis, is lacking.

In Italy the disease known as " brusone " has been attributed to the attack of *Piricularia Oryzæ*. This fungus is occasionally the

cause of serious damage to paddy in certain areas in Madras, and is also known in Japan, and is doubtless responsible for a proportion of the damage known as "brusone." The symptoms of "brusone" are a reddening of the plant, feeble development of the fine root system and lack of grain, the last two characters agreeing with the chief symptoms of straighthead. Brizi in a series of water cultures showed that a diseased condition of paddy could be produced by want of aeration, the condition of the roots in the non-aerated cultures resembling that of the roots of plants suffering from "brusone." Further experiments showed that the addition of an alga to non-aerated water cultures, in which the liquid contained a little CO_2 in solution, enabled the plants to produce a healthy growth. Brizi concluded that the algal film present on the surface of paddy fields must consume much of the CO_2 given off by the roots and largely increase the quantity of dissolved oxygen in the water. He states that "brusone" is generally worse in compact impermeable soils and especially in the presence of excess of organic manures which in their putrefaction lead to intense reduction.

The important fact which emerges from these experiments by Brizi is that a diseased condition of paddy has been shown to be dependent upon a deficiency in the supply of oxygen to the roots. This however can scarcely be accepted as an explanation of "brusone", as not all impermeable soils produce this condition and the disease is also known to occur on percolating soils. More extensive knowledge of the biochemical processes involved in the activity of the micro-organisms of soils is required before we can postulate any general cause for this group of diseases.

IMPRESSIONS OF THE INTERNATIONAL POTATO CONFERENCE, LONDON, NOVEMBER 1921.

BY

W. BURNS, D.Sc.,

Economic Botanist to the Government of Bombay.

The First International Conference dealing with the potato, its culture, breeding, commerce and diseases was held in London on November 16, 17 and 18, 1921. This conference owed its being to the Royal Horticultural Society, acting in conjunction with the Ministry of Agriculture. The meetings proper of the conference were held in the lecture room of the Royal Horticultural Society's building in Vincent Square, that Mecca of British horticulturists. A full account of the conference will appear in the publications of the Society shortly, and it is understood that the papers read will also be printed in full. It is not the purpose of the writer to go into exhaustive detail regarding either papers or discussions, but merely to mention various points which struck him personally.

A limited number of galley proofs of papers were available at the beginning of each meeting. The readers of papers did their best to be brief, often omitting considerable passages (which were of course in type), but even with this abbreviation one felt that one would have liked more time for discussion. Such opportunities for the exchange of views between workers in different countries are so rare. One would have liked, too, some additional time for the informal exchange of views.

Experience of this and other conferences forces one to the conclusion that all papers should be circulated to members at least a

week before the meetings and that the whole time of meetings should be devoted to discussion led off by some chosen speakers.

In the discussions there revealed itself the old antagonism between the practical man and the scientist. This was good natured certainly, but unmistakable.

The farmer who grows potatoes for profit and the firms or individuals who produce new strains for commercial purposes are fairly well satisfied with themselves and not fully convinced of the necessity of more science. The attitude is perfectly just, since if the scientific man is not indispensable he is not wanted at all. In the combating of diseases the help of the scientist is, one thinks, always welcome, if he can give some real remedy or show that he is on the way to a remedy. In the realm of breeding, so far as the potato is concerned, the commercial grower has certainly done wonders, and the scientific student of the genetics of potatoes is only a little way on the road yet. In this matter as in others, and in all countries, it seems to the writer that the scientific man has to make known even yet what the method of science is in order that he may convince the public who pay him that with this method results are certain and that when the results are obtained progress even in the directions in which practical men have done most is bound to be both more rapid and more secure.

The help which the scientific man can give was well illustrated in the discussion on bud variation of potatoes. There has been considerable discussion of this point in gardening papers recently with a good deal of argument both for and against. This discussion was renewed at the meetings of the conference. By bud variation in the potato has been so far meant bud variation in tubers, *i.e.*, the production of aberrant tubers. Now there is no *à priori* reason why this should not occur but satisfactory.

There is no reason why the practical man should not use the scientific method. His results would be no less good and his explanations of them would be not only sounder but such as would lead himself and others further along the line of powers over nature.

Much of the interest of the meeting was centred on wart disease. This has not yet been found in India, and the statement of the

Indian delegation to this effect elicited the fact that wart disease is also unknown in France although it has been open to infection from potatoes imported from Britain and from the crops grown by the Germans during their occupation. No Italian delegate being present, it was impossible to learn directly whether Italy, the source of most of the Indian seed potatoes, was, like France, also free from wart. There is something here rather mysterious.

The discussion brought out clearly the fact that the causes of immunity to wart are not known. One pathologist put forward the theory that immunity might not be permanent and might break down. In this direction there is certainly room for much fundamental research. The potato blight due to *Phytophthora infestans* (which does not trouble the potato crop in the plains of India) was the subject of some discussion. The oospores of this fungus have now been found and they or the perennating mycelium or both may be responsible for the passing on of the disease from one season to another.

The experiments on the inheritance of wart disease described are too immature yet to permit of any definite opinion, but the extraordinary fact was put before the meeting that both immune and susceptible varieties produce a progeny in which some seedlings are susceptible and some immune.

Until a true breeding immune or susceptible race is discovered, therefore, it is impossible to analyse satisfactorily the genetic constitution of the commercial varieties, many if not most of them being of very mixed descent.

Of the other diseases dealt with, the obscure group including mosaic and leaf curl attracted a good deal of attention, the more because the well-known Dutch scientist, Dr. Quanjer, whose work on these diseases is well known, was there in person to deal with the subject. These diseases have not been noticed by workers in India as far as the writer is aware.

The Indian delegation put before the conference their difficulties regarding soil fungi and storage rots but there was very little discussion on these matters. It is worth noting that India was the only tropical country represented, and as the problems of potato growing

in the tropics are undoubtedly special there was not so much discussion on the tropical aspects of the various questions.

This is not to be taken as meaning that the Indian point of view did not receive attention. Throughout the conference the Indian delegation were heard with interest, and in the first meeting the writer was specially called on to explain the Indian situation.

The commercial uses of the potato were dealt within a comprehensive paper. Out of this paper and the discussion following it appeared that in Britain the production of potato farina has been a failure, while on the Continent, and particularly in Holland, it has been successful. Japanese competition, however, was now tending to interfere with the Dutch industry. One wishes that one could have heard someone who had actually been in the business.

The question of degeneration of varieties received considerable attention. The opinion was expressed by a representative of the breeding industry that it did not matter if a variety lasted only 20 years or so, as there would be many new varieties in the market by that time to take its place. Several scientists gave evidence that degeneration is a result of disease infection. The matter is another of the questions on which we cannot be said to have reached finality.

In conclusion, one may hope that this will not be the last of these conferences. The meeting of scientists and practical men of various countries is most valuable. The only thing necessary is that they should meet as much as possible during the time of the conference.

CONDITIONS INFLUENCING THE DISTRIBUTION OF GRAIN SMUT (*SPHACELOTHECA SORGHI*) OF JOWAR (*SORGHUM*) IN INDIA.*

BY

G. S. KULKARNI, M.Ag.,

Assistant Professor of Mycology, Agricultural College, Poona.

This is the commonest smut of *jowar* in India, as in most countries where the crop is cultivated. It is also the most destructive disease in this country causing enormous losses, especially in Bombay, Madras, Central Provinces and Burma. It is, however, very scarce, at any rate not so abundant, in the Indo-Gangetic plains comprising the provinces of Sind, the Punjab, the United Provinces and Bihar, though it is met with in the submontane parts of the United Provinces and the Punjab. In a previous publication,[1] on the evidence obtained from the germination study of the spores of this fungus, it was suggested that *temperature* had an important bearing on the occurrence of the disease. The results of the potculture experiments carried out since then have given ample proofs of this fact and they have been confirmed by field trials. The account given below contains the details.

In order to follow these experiments a short account of the results of the previous work[2] will be necessary and therefore has been quoted.

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* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

[1] Kulkarni, G. S. Smuts of Jowar (*Sorghum*) in the Bombay Presidency. *Pusa Agri. Res. Inst. Bull.* 78, p. 13.

[2] *Ibid*, pp. 12 and 13.

"In the case of *grain smut* infection occurs with seed-borne spores. The germ-tube of the spore or of the sporidium comes in contact with the young cells of the seedling. Entry is effected by the hyphæ growing through the epidermal cells of the primary shoot below the soil level, and the susceptibility is limited to the period of about 2 to 6 days between the moment of germination and the emergence of the first green leaf from its colourless sheath. This period varies somewhat according to temperature."

"At low temperatures *jowar* will germinate very slowly. Its rate of germination increases as the temperature rises and is at its optimum at 36°C. to 40°C. Thus at 16°C. it takes from 4 to 6 days for the first leaf to appear. At 20° to 23°C. it requires 3 to 4 days, at 30°C. 2 to 3 days, and at 37°C. 1½ to 2 days. The spores of the grain-smut germinate quite easily at moderate temperatures. The optimum temperature is 20° to 23°C., below or above which the rate of germination falls. At 16°C. about 70 per cent. of the spores germinate, at 20° to 23°C. about 90 per cent., at 30°C. about 60 per cent. and at 37°C. only 1 to 2 per cent., while at 40°C. nil. If the temperature of germination be compared for the spores and the *jowar* seeds, it is found that infection is most likely to succeed at moderate temperatures, say, between 16°C. and 30°C., at which the spores germinate very freely, while the growth of the *jowar* seedling is retarded so that the susceptible stage is prolonged."

Usually *jowar* is sown in India in June-July, when the average temperature of the places where *jowar* is cultivated, *viz.*, in Bombay, Madras, Central Provinces and Burma, is between 21° and 30°C. This temperature being most favourable for the spores to germinate, *jowar* grows up rather slowly and consequently the susceptible stage is prolonged and infection is more certain. In the Indo-Gangetic plain, however, where the average temperature for these months is between 30° and 40°C., which is too high for the spores to germinate but more favourable for the rapid growth of *jowar* seedlings, the susceptible stage is passed over soon, and therefore infection is very little.

In order to test this assumption, pot experiments were done in the Mycological Laboratory of the Agricultural College, Poona. A small quantity of *jowar* seed was taken and was infected with the fresh spores of the grain smut.

Infection was done by sprinkling the spores on the grain. The seed was then sown into two pots. One pot was incubated at 40°C. for three days, and the other at 25°C. which was the room temperature of the laboratory. On the fourth day the pots were taken out and the seedlings were transplanted in big pots, and were kept under observation till the plants flowered. The results were as under :—

Serial No.	No. of plants in each pot	No. of smutted plants	REMARKS
Pot No. 1 ..	20	nil	At the time of germination incubated at 40°C. for three days, afterwards transplanted into four pots
" " 2 ..	13		
" " 3 ..	14		
" " 4 ..	22		
" " 1 ..	17	9	At the time of germination incubated at the room temperature of the laboratory, *viz.*, 25°C., and then transplanted into four pots on the fourth day.
" " 2 ..	12	6	
" " 3 ..	21	12	
" " 4 ..	14	8	

In the first series of pot experiments there was no smut attack, since no infection took place as the spores do not germinate at 40°C. temperature, while in the second series the attack was due to the free germination of spores at the low temperature of 25°C. It thus clearly shows that temperature is a limiting factor to the smut attack of *jowar* crop.

FIELD EXPERIMENTS.

These experiments were carried out at Pusa* in Bihar, and at the Government farms at Larkhana and Jacobabad in Sind, with the following results.

Place	Treatment of seed	Average temperature at the sowing time	Percentage of attack
	Experiments in 1918.		
Pusa plot	Seed was mixed with spores before sowing	27° to 32°C. from 26th to 30th June, 1918.	12
Larkhana plot	Do. ..	26° to 34°C. from 22nd to 26th July, 1918.	10
Poona College Farm plot (Control).	Do. ..	27°C. from 26th to 29th June, 1918.	32
	Experiments in 1920.		
Jacobabad plot	Seed was mixed with spores before sowing	36° to 40°C. from 11th to 14th July, 1920.	nil
Poona College Farm plot (Control)	Do. ..	25°C. from 19th to 21st June, 1920.	65

Smut appeared on the Pusa and Larkhana plots in 1918 owing to the exceptionally low temperatures that prevailed at sowing time. The degree of attack was, however, much less as compared with that of the control plot where it was 32 per cent. The results of 1920 at Jacobabad are, however, quite definite. Smut attack was nil owing to the high temperature at sowing time, while it was considerable in the control plot (65 per cent.)

These experiments, therefore, both in pot and field, go to show that *temperature* is the controlling factor in the distribution of the grain smut in India.

* Writer's thanks are due to Dr. Butler, Imperial Mycologist, Pusa, and to the Farm Superintendents of Larkhana and Jacobabad for having carried out the field experiments.

Selected Article

THE PROBLEM OF THE WITCHWEED.*

BY

H. H. W. PEARSON, Sc.D., F.L.S.

General.

THE witchweed (*Striga lutea*, Lour.), also known in various districts as the redweed, rooibloem, rooiboschje, mealie-gift, isona, molvane, etc., is a root parasite belonging to the family Scrophulariaceæ, which includes many other species living in the same manner. These are all flowering plants whose roots become intimately attached to those of other plants, from which they derive some or all of the food material which they require. The loss of material which is thus suffered by the plant attacked (the "host" plant) causes it permanent injury; its growth and development are impeded, and frequently it dies before reaching the seed-bearing stage.

These root parasites are very numerous and are found in all the habitable parts of the world. In a state of nature, growing upon wild plants native in the same locality, they are not as a rule productive of great harm. A condition of equilibrium, resulting from a long-continued struggle for existence between contending species, has been established. The host plants are able to hold their own against the parasite; on the other hand, the parasite, increasing perhaps at one period and waning at another, continues to exist and set seed. But when new land is cultivated these conditions of equilibrium are destroyed. If the crop grown on newly broken soil should be a suitable host, the parasite, once established on it, is likely to increase and multiply very much more rapidly than

* *Dept. Agri. Union of South Africa Bull. 40.*

ever before; and if the crop is cultivated over a wide area it may quickly spread over a whole country. Consequently it is not surprising that, with the rapid extension of agriculture during recent years, parasites of various kinds and root parasites in particular, formerly unknown, have many of them become of great economic importance. In South Africa there are perhaps 150 species of root parasites growing wild upon the native vegetation in various parts of the country. So far only one of them, the witchweed, has become well known as a parasite upon cultivated field crops. At least two others, however, occur occasionally, and there are others which may at any time force themselves upon the attention of the farmers of the country.

The witchweed is probably a true native of South Africa. It occurs quite commonly in uncultivated land as a parasite upon various native grasses in Zululand and Natal and, occasionally, in the Transvaal. It is, however, probable that originally it was confined to the south-eastern coast belt and has spread inland with the extension of maize cultivation. It occurs also abundantly in Tropical Africa, Egypt, Madagascar, Arabia, Ceylon, Bengal, Punjab, Sind, Deccan, Siam, Java, and China. Outside Africa it apparently does not inflict serious injury upon any field crop, though in India it is said to be of common occurrence in the rice-fields.

The root parasites may be divided into three classes, according to the extent of their parasitism and of the injury which they inflict upon their hosts. Very many of them—the least harmful—are green plants, with small but green leaves which take little more than water from their hosts; such, for example, is the common English wayside weed popularly known as the "eyebright." Others are at first subterranean, subsisting entirely at the expense of the host plant for a few weeks, months, or years; at length the stem appears above the ground, develops green leaves, produces flowers and seed, and then dies. To this class the witchweed belongs; for a period varying from six weeks to three months its sickly white stems are not seen above the ground; their growth is supported entirely by the host plant. It is during this first part of its life that the greatest harm is suffered by the maize. There is a third class whose members never

become green at all; these are fed entirely by the host plants, and they are therefore more injurious than either of the two preceding classes. An example of these is the broomrape (*Orobanche*), which within recent years has done great damage to hemp, tobacco, and other crops in the southern United States and elsewhere.

The witchweed is now very widely distributed throughout the maize-growing districts in South Africa. As a parasite on the maize it is reported to occur in the following localities:—

Natal.

Alexandra.	Ipolela	New Hanover.
Alfred.	Ixopo.	Nkandhla.
Bergville.	Klip River.	Paulpietersberg.
Camperdown	Lions River.	Richmond.
Dundee.	Lower Tugela.	Umgeni.
Entonjaneni.	Lower Umzimkulu.	Umlazi.
Eshowe.	Mahlabatini.	Umvoti.
Estcourt.	Mtunzini.	Utrecht.
Helpmakaar.	Ndwandwe.	Vryheid.
Hlabisa.	Newcastle.	Weenen.
Inanda.		

Transvaal.

Aapies River.	Klip River (2).	Secocoeni.
Amsterdam.	Krugersdorp.	Selons River.
Barberton.	Lake Chrissie.	Springbok Flats.
Bethal.	Mapoch.	Steelpoort.
Bronkhorstspruit.	Nylstroom.	Steenkoolspruit.
Carolina.	Ohrigstad.	Swartruggens.
Elands River.	Olifants River.	Upper Schoonspruit.
Gatsrand.	Palala.	Waterval.
Groot Marico.	Piet Retief.	White River.
Hex River.	Potgieter.	Witwatersberg.
Highveld (2).	Roodekoppen.	Witwatersrand.
Klein Spelonken.	Saltpan.	Woodbush.

Orange Free State.

Kroonstad.	Ventersburg.	Vrede.

Cape Province.

Fort Beaufort.

In spite of this very wide distribution in South Africa there are still many maize-growing districts in which the witchweed is not

known to have appeared or occurs so sparingly that it attracts no attention. This is particularly the case on the high veld and in the Cape Province*. Among the natural checks to its spreading, differences of temperature and of soil are probably paramount. The critical temperatures for the germination of the seed are not at present determined; it is hoped that definite information regarding this question will be obtained shortly. The question of the effects of soil differences will be referred to later.

In addition to the maize, it also finds favourable host plants in the sugarcane and the kaffir corn. At Potchefstroom it grows on the fodder-grass *Paspalum dilatatum*, and in one single instance it was found to have established itself upon the monkey-nut. These host plants and the native grasses on which it occurs so abundantly in the wild and semi-wild states are, however, none of them so favourable for its growth as the maize. It will be noted that it shows a marked preference for members of the grass family, and that it has become established upon at least one fodder-grass (*Paspalum*) of recent introduction into South Africa. Therefore, quite independently of its effects upon the maize, this parasite is deserving of careful attention. Any new fodder-grass may furnish a host as favourable to the demands of the witchweed as the maize itself. The parasitism of the witchweed upon the maize has become very serious, because for at least thirty years no serious attempt has been made to deal with it, and it has been allowed to spread over the country almost unnoticed. If the matter had been taken in hand some years ago, the difficulty of dealing with it would have been very much less than it is now. If, therefore, it shows any sign of growing luxuriantly upon a new crop, energetic measures for effecting its eradication should be adopted without delay.

The general appearance of the witchweed will be familiar to most growers of maize. * * * *
* * * * * *
* * * During the first few weeks of its existence it does not come above ground at all. Its stems and

* No information regarding the native territories is available.

minute leaves have no green colour ; they are living entirely at the expense of the maize plant, causing a very serious drain upon its resources. If the maize plant is infected in the seedling stage, this drain comes at a time when it is least able to meet it ; it is still a young plant needing all the food it can get for the purposes of its own growth. Therefore we have a combination of circumstances calculated to cause the maximum of harm to the maize, *viz.*, a hungry parasite relying entirely upon the host plant for its food ; a host plant hastening to establish itself, having no reserves from which to meet these demands, and therefore compelled to satisfy them at the expense of its own growth and development. Consequently by the time that the witchweed appears above the ground the damage is done.

Botanical investigation.

The way in which the witchweed attaches itself to the mealie root was described by Mr. Fuller.[1] A number of branches from the lower part of the plant spread out in the soil and produce bell-shaped out-growths (haustoria), which fit closely on the surface of the root. From the mouth of the " bell " there arise out-growths which pierce the tissues of the maize nearly to the centre of the root and absorb its juices. The detailed structure of the haustorium and of the connection which it establishes with the tissues of the mealie root have been studied by Miss Stephens.[2] These structures resemble in all essentials those of the haustoria of many other root parasites. It is, however, necessary to refer to them here in order to make it clear that when once the connection is established nothing can be done to save the plant that is attacked. The disturbance caused in the soil by the ordinary methods of cultivation undoubtedly gives momentary relief by breaking some of these connections, but when the underground top of a young witchweed plant is broken off, the lower part branches more profusely, and, in the end, the number of connections established may even be greater than it was

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[1] Fuller, C. *First Report of the Government Entomologist, Natal*, 1899-1900, pp. 20–22, Plate V.

[2] Stephens, E. L. *Annals of Botany*, XXVI, p. 1067.

before. It is hardly necessary to point out that the damage to the maize bears a rough proportion to the number of connections ; two equal holes in the bottom of a water-tank will empty it more rapidly than one.

Since, then, we can do little or nothing for the host plant when it is attacked, we must consider whether it is possible to prevent the attack. To this end it is necessary to investigate the whole life-history of the parasite, particularly that part of it which immediately precedes infection.

It was quite clear at the beginning of this investigation that the maize became infected through the seed of the witchweed, but it was not certain that this was the only method of infection. This doubt has now been settled. The witchweed plant dies when it has set its seed, or when the maize plant on which it is living dies. It is a true parasite and has not the power to become a saprophyte. Like the maize, therefore, it is an annual*, and at the end of the season leaves nothing except the seed with which to start the next year's crop. Whether it is an annual in the wild state is not known. If not, then it has become one in adapting itself to live as a semi-parasite upon an annual host. This simplifies the problem to some extent, for it enables us to concentrate our attention on the seed.

The first points then to be investigated are the distribution and germination of the witchweed seed and the conditions which control them. Some of the characters of the seed have already been mentioned. It is very small and light (Fig. 1) ; it is produced in enormous numbers. Its dark coloured coat is rough and sculptured (Fig. 1). Mixed with a dark soil, it is quite indistinguishable, except by the aid of the microscope. These facts give a clue to the means by which, within a comparatively few years, the witchweed has spread over so large an area. In the districts in which maize growing is practised on a large scale, the rains fall in the summer ; the winters are dry. Strong winds, driving great clouds of dust in front of them, occur during the winter. If the dust arises from

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* See postscript.

a field whose soil contains witchweed seed, it is quite impossible that it should not carry some of the seed with it, for the seed is smaller, and bulk for bulk lighter, than many of the mineral particles of the dust. A gentle rain washes the seed into the ground ; if the rain is so heavy as to cause a surface wash, seed will be carried off by the flowing water ; this is, no doubt, the

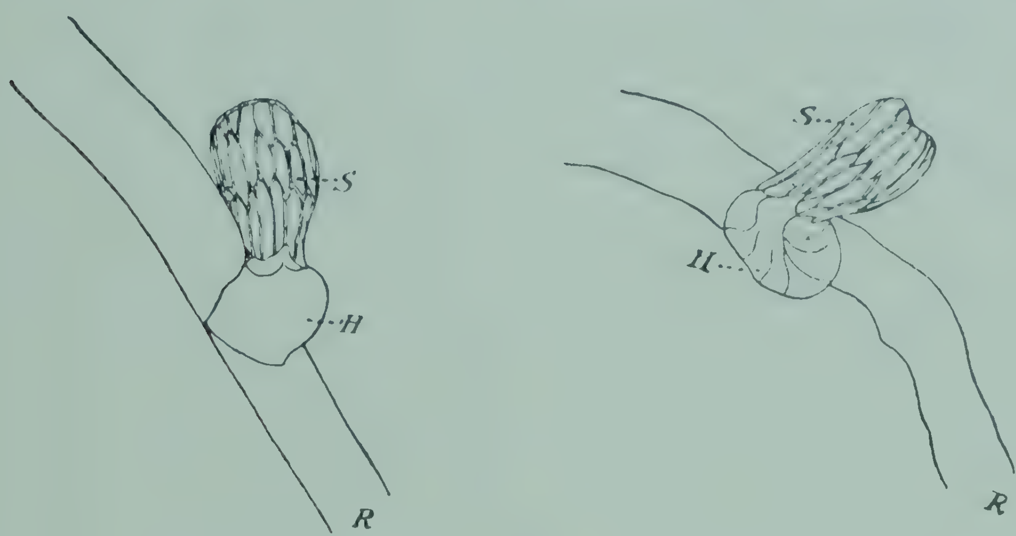

FIG. 1. FIG. 2.
R, Maize-root on which a witchweed seedling has established itself ; *S*, Seed-coat ; H, Primary haustorium.

explanation of the fact that the lower part of a field is frequently more thoroughly infected than parts which are at higher elevations. This is probably by far the most important method of seed distribution. If the maize seed were small and not easily separable from that of the witchweed, the question of distribution would be more complicated. A little seed is probably carried now and again with the maize from infected land, but this method of distribution can rarely be of great importance in comparison with that by the wind.

If, then, we can either prevent the witchweed from setting seed or destroy the seed before it germinates or kill the young witchweed seedling before it becomes attached to the maize root, the problem is solved. These alternatives may be considered separately.

The obvious method of preventing the seed being formed is to uproot the plant before it flowers. It is always possible to do

this by the ordinary methods of cultivation. It is only a question of labour supply and expense. This was pointed out by Mr. Fuller more than ten years ago[1]. It should certainly be adopted in all cases in which the infection is small. It has already been said that this treatment will not save that part of the crop which is attacked, but it will prevent the further infection of the land in following years. Where the crop is badly infected, it should be ploughed in before the witchweed flowers.

A few years ago it was attempted to obtain the same result by spraying[2] the witchweed plants with a solution of copper sulphate. These experiments were successful to a certain extent, but no development of this method is likely to be effective in dealing with the problem as a whole. If the maize plant is not well established, it will be injured as well as the witchweed. Although the aerial stems of the parasite may be destroyed, those which are still subterranean will hardly be affected, and in order to prevent the formation of seed the treatment must be repeated at intervals; if the infection is abundant, the maize plant will be ruined as a crop before the witchweed comes above the ground. Therefore the risk to the maize plant and the expense of the treatment, if it is to be made really effective, are so great that it would probably be cheaper, and certainly better, to resort to the ordinary methods of cultivation.

Most of the root parasites of the same group as the witchweed are sun-loving plants.[3] There can be no doubt that the witchweed has the same character. Its production of flowers, and therefore of seed, would certainly be interfered with to a greater or less extent by the conditions of dense shade. Unfortunately the heavy infection of a maize crop brings in its train the reduction of shade, and therefore improves the conditions for free flowering and seeding. On the other hand, it is very probable that it is to some extent kept in check in the cane-fields of Natal by the dense growth of the sugarcane, which is sufficient to prevent direct sunlight from

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[1] Fuller, C. *First Report of the Government Entomologist, Natal*, Pietermaritzburg, 1901.

[2] Watt, R. D. *Transvaal Agricultural Journal*, July 1909. Weir, C. W. *Agricultural Journal*, May 1911.

[3] Heinricher. *Die Aufzucht und Kultur der Parasitischen Samenpflanzen*, Jena, 1910.

reaching small weeds growing amongst it. At the same time there is every reason to believe that other and more important factors are concerned here, and it is likely that one of these is that the difference between the concentration of the cell sap of the sugar-cane and the witchweed is less than between the maize and the witchweed.[1]

The next point to be considered is the possibility of rendering the witchweed seed harmless after it has reached the soil. The small size, great numbers, and hard resistant coat of the seed make it difficult to kill. One condition which it cannot withstand is that of high temperature. In certain stages of its development it is not injured by being immersed in water at a temperature of 80°C. for fifteen seconds (Experiment 57). But it cannot resist temperatures considerably above that of boiling water. It has already been pointed out[2] that the burning of rubbish on the field after harvest will certainly kill the seed on the near surface of the soil. It will probably be only occasionally possible to put this into practice, but where it is possible it cannot fail to act beneficially on badly infected land by reducing the amount of living seed in the soil. It is further not improbable that there may be other methods, both more effective and more easily applied, of killing the seed in the soil. These are at present under investigation.

But even if the seed cannot be killed there are still other ways of rendering it harmless. One of these is to cease planting maize, for the present, on land known to be badly infected. Apart from the question of the conditions controlling the germination of the seed, which will be considered later, it is well known that up to the present the witchweed has not succeeded in establishing itself on a number of South African crops. In fact, as Mr. Fuller and others have urged before, " a rotation of crops is the correct treatment."[3] Long before the white occupation had extended to many areas on which maize is now grown, the Kaffirs were cultivating this crop year after

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[1] MacDougall and Cannon. *The Conditions of Parasitism in Plants—Xenoparasitism* Washington, 1910.

[2] Pearson, H. H. W. *Agricultural Journal,* May 1912.

[3] Fuller, C. *L. c.*

year on the same ground until it became so thoroughly infected that its abandonment became necessary. A similar practice on a larger scale still prevails in very many districts. It is mainly to this fact that the present serious nature of the witchweed problem is due. For his own sake, as well as for that of his neighbours, a farmer who cannot command the means to cope successfully with a heavy crop of witchweed should use the badly infected parts of his farm for crops which are not attacked. Such crops are monkey-nuts, sweet potatoes, teff grass*, potatoes, velvet beans, kaffir corn†, lucerne, sunflowers, pumpkins, etc. The principle of the rotation of crops is now well established in intensive agriculture, and there is no need to discuss it here. It is only necessary to point out that it constitutes what will in nearly all cases be an easily applicable means of keeping the witchweed seed dormant, and therefore for the time being harmless.

There is still another possibility of putting the seed out of harm's way in certain cases, particularly in that of land recently infected. As a temporary measure it must be more or less effective ; there is, however, no sufficient reason to hope that, in general, it can be of permanent benefit. The maize, as every one knows, is a shallow-rooting plant. If the land is ploughed as deeply as possible, the seed which lies near the surface will be buried so deeply that the maize will be well established before its roots penetrate far enough to be seriously infected. This in itself is an important gain, for early infection is much more harmful than that which occurs later. Also, when the witchweed seed germinates at some depth below the surface, particularly when germination does not occur until the maize is well grown, there is a considerable probability that the witchweed plant will not have time to reach the surface, and still more that it will not be able to flower and set seed. And further, it is probable that the conditions near the surface of the soil are more favourable for germination than those prevailing at a greater depth. If, then, the soil at the surface does not become reinfected by

* Reported to be immune.

† This plant is attacked, but usually the infection is so small that the witchweed is easily dealt with by cultivation.

wind-carried seed, deep ploughing should be beneficial until the land is deeply ploughed for the second time. The seeds of other root parasites whose life-histories have been investigated are known to remain alive for many years in the soil if no opportunity for germination presents[1] itself; there is a good deal of indirect evidence that the seeds of the witchweed possess the same property, and, *a priori*, it would be most surprising if they did not. It is therefore probable that at least some of the seeds buried by deep ploughing, if brought to the surface again within the following ten or fifteen years, will be still alive and able to infect a mealie crop as well as if they had never been buried. And in any case if, after ploughing, the surface becomes reinfected by wind-blown seed, we are no better off than before.

Germination of the seed.

We now come to the consideration of the germination of the witchweed seed and of the events which occur between the beginning of germination and the first infection of the maize-root. These must be carefully studied before we can make any reasonably promising attempt to prevent the infection.

Previous attempts to make the seeds germinate in cultivation had been unsuccessful[2]. The nature of Mr. Fuller's and other experiments is not described, but the fact that they were not successful made it probable that germination only occurs when the seed lies in the immediate vicinity of the root of a suitable host. While the seeds of many root parasites will germinate in the absence of a host[3], there are a few (*e.g.*, Tozzia) which behave differently. It is clearly of the greatest economic importance that there should be no doubt upon this point. If the seeds of the witchweed will germinate in clean soil in the absence of a host, the ordinary agricultural process of fallowing should suffice to free the land of witchweed. If, however, germination only occurs as the result of the action of a stimulus owing its origin to the presence of a suitable host, then the problem is greatly complicated.

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[1] Heinricher. *L. c.* De la Germination des Graines des Plantes Parasites.
[2] Fuller, C. *L. c.*, p. 22. [3] Heinricher. *L. c.*

During some months, therefore, various methods of germinating the seed away from a living host were tried ; all were unsuccessful. The seed was sown in water (drop-cultures), on damp moss, on porous pottery, on soil (including pure sand), and on gelatine. When no germination was obtained, it seemed possible that the addition of the expressed juice of the maize-root might give a different result. The experiments were therefore repeated, the maize juices being added to each of the substrata used before. Again no satisfactory result was obtained, the seeds sown on gelatine swelled and in a few the seed-coat cracked, but no root appeared. These methods were then abandoned, and for the time at least the conclusion was adopted that the seed only germinated in the presence of the host. This conclusion was considerably strengthened by the discovery that witchweed seeds of the same gathering as those used before germinated freely in the presence of a living maize-root. This is easily demonstrated in the following manner :—

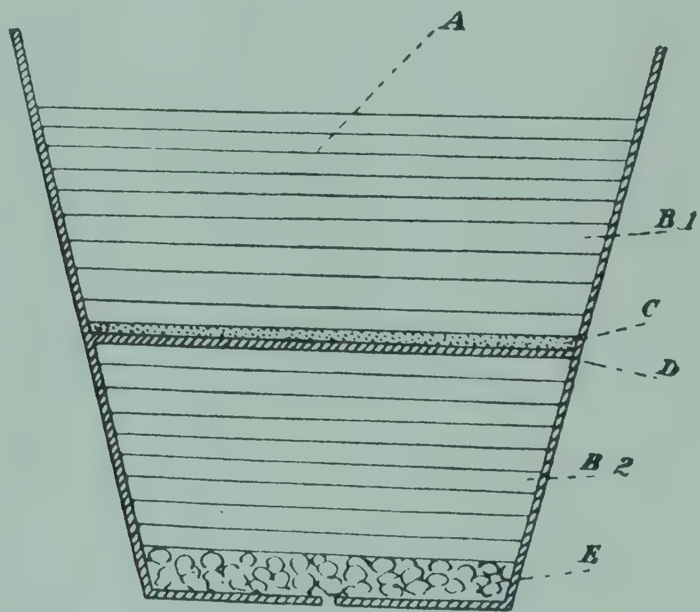

Fig. 3. Diagram of section through a flowerpot.
A, Maize seed ; *B*$_1$, *B*$_2$, Soil ; *C*, Mixture of sand and witchweed seed ; *D*, Layer of coarse muslin or silicate cotton ; *E*, Stones.

The culture, arranged as shown in Fig. 3, is kept sufficiently moist to ensure the germination of the maize and at a temperature ranging from about 15°C. at night to 25°–30° C. during the day. After 10–12 days, the pot is inverted and its contents are shaken out. On removing the muslin (D) and the soil B_2, which now lies

above it, the witchweed seed is exposed for examination. If the maize-root has grown into or through the layer C and other conditions have been favourable, young seedlings of the witchweed will be found.

The following conditions are necessary for germination :—

1. *Temperature.* Beyond the statement just made there is at present no precise information. The optimum temperature probably lies between 25°C. and 30°C.

2. *Soil.* That the nature of the soil is of great importance there can be no doubt. For example, on Springbok Flats contiguous areas of black turf and red loam soils bear very different crops of witchweed, though they must both contain abundant seed. Here we meet again with the old difficulty of the relative importance of the physical, chemical, and biological characters of the soil. The study of the agricultural soils in South Africa is not yet advanced beyond its initial stages, and the evidence required for a discussion of this difficult question is not available. The following analyses are, however, instructive :—

No. 1. Comparative analyses[1] *of three soils from Springbok Flats, viz.*—

A_1, A_2. "Black turf" (in which the witchweed germinates sparingly).

B. Reddish loam (in which the witchweed germinates profusely).

	A 1737 Per cent.	A_2 1738 Per cent.	B 1739 Per cent.
Stones	1·00	0·00	0·00
COMPOSITION OF AIR-DRY FINE EARTH—			
Moisture	5·96	9·11	9·45
Loss on ignition	6 01	7·17	7·37
Insoluble matter	70·89	63·02	62·49
Iron oxide and alumina	15·05	19·25	19·55
Lime	1·49	1·02	0·75
Magnesia	0·17	0·10	0·12
Potash	0·30	0·45	0·46
Phosphoric acid	0·07	0·07	0·08
	100·94	100·19	100·27
Nitrogen	0·126	0·133	0·137
Available potash	0·0083	0·0140	0·0120
Available phosphoric acid	0·0143	0·0059	0·0050

[1] *Report of the Department of Agriculture*, 31st May, 1910, to 31st December, 1911. *Appendix XIX* (*Report of Division of Chemistry*), p. 379.

For a second pair of analyses I am indebted to the courtesy of Mr. E. R. Sawer (formerly Director of the Cedara Experimental Farm) and of members of the scientific staff of the station.

Central Experiment Farm,
Cedara, Natal,
24th, February, 1912.

No. 2. Reports on samples of soils taken by the Biologist from the farms Driefontein and Waterfall, near Cedara.

I. Soil from upper portion of Driefontein farm, near Isaac Mkize's kraal; never known to have grown witchweed. Dark clayey loam, containing a fair amount of gravel of impure limonite.

II. Soil from lower portion of Waterfall farm, near the railway line, from ground known to be badly infected with witchweed. Dark red loam, with only a small proportion of sandy matter, but fairly porous owing to excessive amount of iron oxide present.

Results of analysis.

	I. Driefontein Per cent.	II. Waterfall Per cent.
Gravel	0·9	0·4
Reaction to litmus ..	Neutral	Neutral
Hygroscopic moisture ..	8·36	11·0
Loss on ignition	7·87	10·91
Total lime (CaO)	0·24	0·33
Total potash (K_2O) ..	0·09	0·12
Total phosphoric oxide (P_2O_5) ..	0·10	0·12
Chlorine	0·009	0·007
Nitrogen	0·18	0·18
Available potash	0·011	0·035
Available phosphoric oxide ..	0·002	0·002
Water capacity (capillary water)	41·9	42·0
	mm.	mm.
Capillarity—After 1 hour ..	79	92
" " 12 hours ..	231	277
" " 24 " ..	299	345
" " 120 " ..	513	548

Mr. Sawer further states with reference to these analyses: "The soil from the Waterfall farm, which is badly infected with witchweed, is, however, in every respect a better arable type than that from the Driefontein farm."

Many experiments to test the germination of witchweed seeds in the two types of soil from Springbok Flats (" black turf " and " reddish loam ") have established the fact that the seeds germinate readily in the reddish loam and sparingly in the black turf. If this difference of behaviour is due to differences in chemical composition of the soil, we should expect them to be well marked. If the samples A_1 and A_2 represent approximately the range of variation in the composition of the " black turf, " there is no such marked difference between this and the reddish loam. It is true that the latter is relatively poor in lime, but only to the extent of 0·27–0·74 per cent. But at Koedoespoort a soil, not very different from the Springbok Flats reddish loam, produces an abundant crop of witchweed even after a generous dressing with lime.

In the partial analyses of the two Cedara soils there is likewise disclosed no chemical difference which is at all likely to account for the absence of witchweed from No. 1 and its abundance in No. 2. On the other hand, nothing is known in this case as to the germination of the seed in these two soils, and the difference may be due to other causes—such as, for example, some peculiarity in the situation of Driefontein which has so far protected it from becoming infected. It is therefore impossible to draw any conclusions as to the relations between the composition of these soils and the germination of witchweed seed. From the Springbok Flats results, however, we may probably conclude that the more ready germination of the seed in one soil than in another is not due, at least in the main, to differences of chemical composition.

It is much more probable that differences in physical constitution rank high among the determining factors. The soils from the Springbok Flats, called respectively " black turf " (A_1, A_2) and reddish loam (B), are physically very dissimilar. The former is of clayey consistency, adhesive when wet, hard when dry, and comparatively retentive of water. The red loam, on the other hand, is loose and porous, sandy when dry, and quickly " dried out." There is reason to believe that the germination of the witchweed seed is greatly favoured by the physical conditions characteristic of the latter.

3. *Water.* Laboratory cultures have shown very clearly that the amount of water in the soil has a considerable influence upon the germination of the witchweed seed. Even in the reddish loam described above, germination may be entirely prevented by over-watering. So long as there is sufficient water to keep the

Fig. 4. A section through a germinating seed of the same age as those shown in Figs. 1 and 2. *S*, Seed-coat ; *F*, Remains of food-reserve of seed ; *St*, Young stem ; *C*, Cotyledons of the embryo witch-weed plant.

maize plant alive, the drier the soil, the more profuse is the germination of the parasite. This result affords an explanation of certain facts well known to farmers. For example, in many districts it has been observed that the witchweed is much more abundant in dry than in wet seasons. Many farmers have found that a generous application of kraal manure tends to reduce the infection—an effect no doubt partly, but probably not entirely, due to the increased power of retaining water which is thus conferred upon the soil.

4. *Maturity of the seed.* Fresh seed (*i.e.* seed taken direct from the seed vessel just as it becomes ripe) will not usually

germinate even under the most favourable circumstances. In other words, the seed is not ripe when it falls to the ground. The ripening process is completed while it lies on or in the ground during the winter. Witchweed seeds collected near Pretoria and on the Springbok Flats in March 1911 were used in germination experiments in the winter of 1911, but without success. A quantity of this seed mixed with sand was buried 3-4 inches below the soil at Koedoespoort, near Pretoria, on 11th July. It remained there until the last week in October, when it was dug up and sent to Capetown, where it arrived on 30th October. On the same day a sample of this seed was placed in the manner described, below soil in which four maize seeds were sown. On 12th December one of the four maize plants was taken up, and three witchweed seedlings were found attached to its roots. On 28th December a second maize

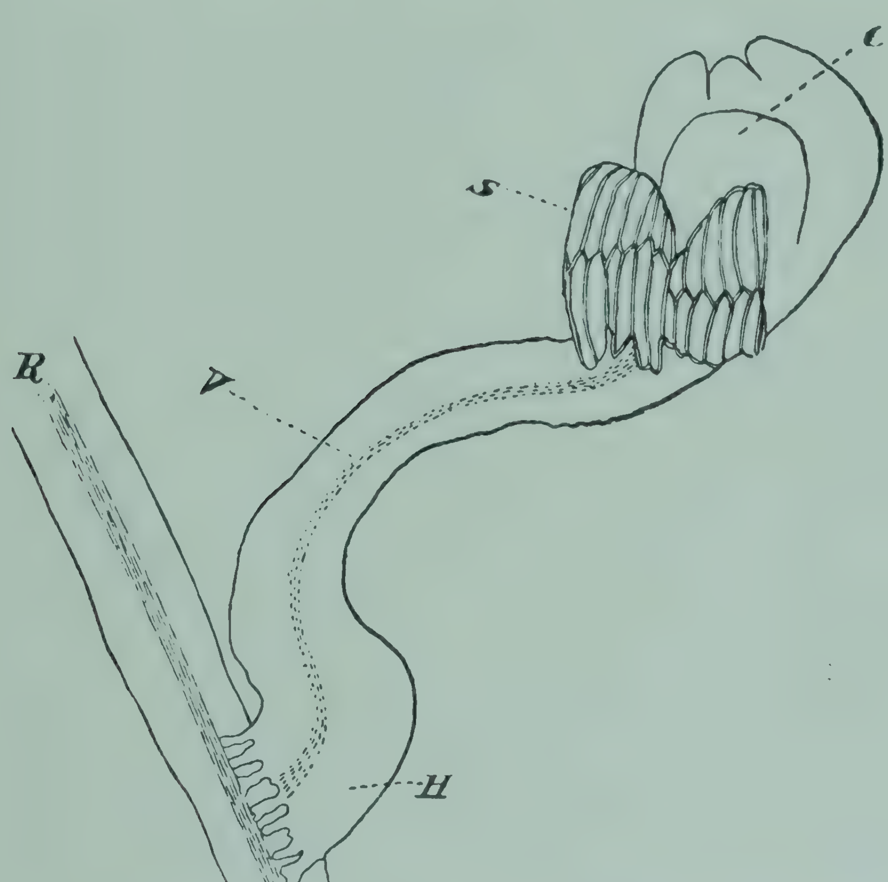

FIG. 5. An older seedling of the witchweed. In this case the root grew or some distance before coming into contact with the maize-root. *C*, Cotyledons of the embryo witchweed plant; *R*, Maize-root, on which a witchweed seedling has established itself; *S*, Seed-coat (The primary haustorium, *H*, seen in optical section); *V*, Vascular strand.

plant was found to be infected in more than thirty places. The third plant died and the fourth was broken during a storm. Clearly, then, a three months' exposure to the ordinary climatic conditions prevailing in winter and spring at Koedoespoort has produced such results that seed which was immature before the exposure has become mature. This behaviour agrees with that shown by other root parasites of this class.[1]

At the same time a very small proportion of a given sample of seeds will frequently germinate within a month or two of gathering if the other conditions are suitable. For example, a bundle of fruiting plants of witchweed were received in Capetown on 14th March, 1912, from Mr. Scott, of Fort Yolland (Zululand). The seeds were separated, mixed with sand, and exposed in a greenhouse six weeks later they were used in the following experiment :—

Experiment 79.

1912, 25th April.—Culture started as described on p. 174.
1912, 6th May.—Numerous germinations found.

The seed of the witchweed has another character in common with that of other root parasites—a peculiarity which has the effect of adapting it in a remarkable manner to the conditions under which it lives, but which has not been satisfactorily explained. Even after a winter's exposure to climatic influences all the seed in a given sample will not germinate even under the most favourable conditions. The proportion that will germinate is considerably below 50 per cent. The larger part appears to be still immature and will probably not be in a condition to germinate until the following or later years. Owing therefore to this progressive maturation of the seed, soil once infected is infected for a period of years. As to the length of this period there is no precise information for the witchweed. There is, however, some evidence to show that it is at least as long as twelve years. In other root-parasites the period seems to vary considerably. For example, in Tozzia and in Euphrasia the seed is stated to remain alive in the soil for many years [2]; seeds of

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[1] Heinricher. *L. c.*
[2] Heinricher. *L. c.*

Bartsia, collected in 1895, were sown in February 1906, and germinated in 1907 [1]: seeds of the broomrape, *Orobanche ramosa*, planted in soil in 1889, produced seedlings each year until 1903[2] — some of the seed must, therefore, have remained alive in the soil for

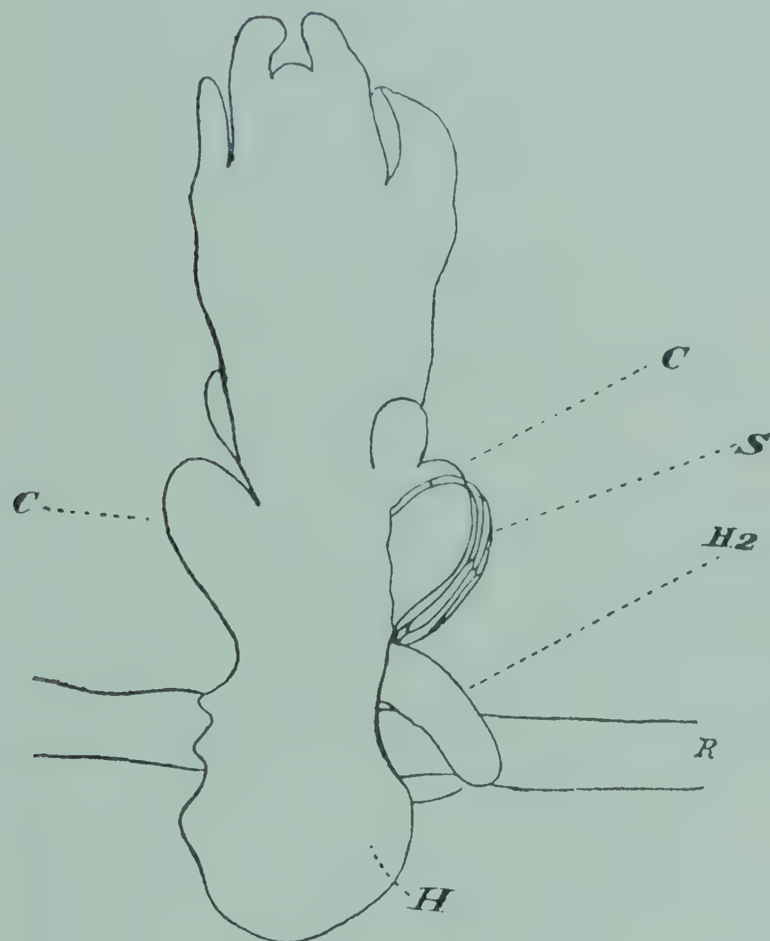

FIG. 6. An older seedling. *C*, Cotyledons of the embryo witchweed plant; *H*. Primary haustorium; H_2, A branch which will give rise to a second haustorium; *R*, Maize-root, on which a witchweed seedling has established itself; *S*, Seed-coat.

fourteen years; seeds of another broomrape, *Orobanche crenata*, on the other hand, lost their power of germinating after lying in the soil for eight years[3]. Although the length of the period during which the witchweed seed will remain alive in the soil is not yet determined, there can be no doubt that it more or less closely

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[1] Heinricher. *L. c.*

[2] Garman, H. The Broomrapes. *Kentucky Agri. Exp. St. Bull.* 105, 1903.

[3] Passerini. *Atti. R. Accad. Econ. Agri. Geogr. Firenze.*, [5], VII (1910), pp. 1–7.

resembles Tozzia, Euphrasia, Bartsia and Orobanche in the progressive maturation of the seed—a fact which greatly increases the

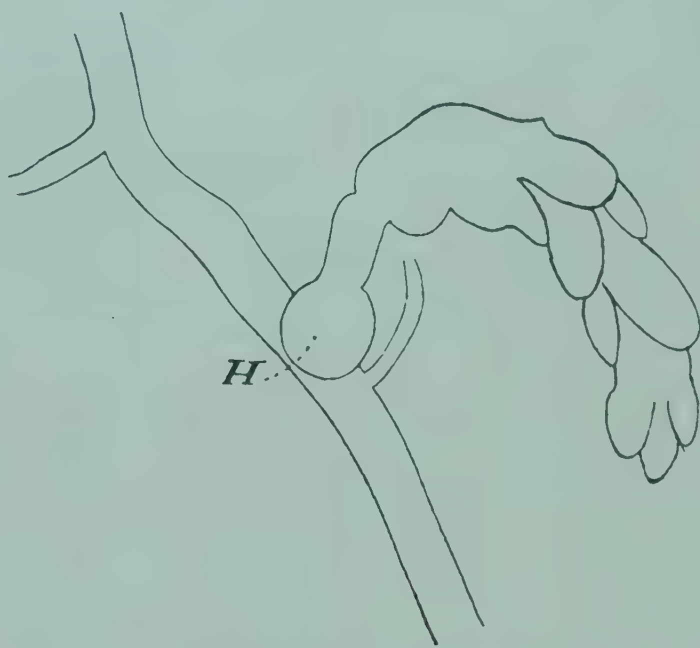

Fig. 7. An older seedling. *H*, Primary haustorium.

difficulty of eradicating it and emphasizes the necessity for using every possible means to prevent the shedding of the seed.

We now come to the details of germination. The narrow end of the seed (the micropyle) marks the position at which the root of the young witchweed seedling will emerge. The first obvious sign of the beginning of germination is a slight swelling at this point. This is followed by a cracking of the seed-coat, which exposes the white tip of the young root. The behaviour of this young root upon its emergence from the seed-coat is determined by the position in which the seed lies when it germinates. It has already been said that the presence of the maize-root is a controlling factor. Most of the seeds which germinate in a given culture will be those which lie in contact with the maize-root or so near to it that they are touched by the root-hairs. Actual contact with either the body of the root or with its root-hairs is, however, not always necessary. Occasionally a seed lying well beyond the range of the longest root-hairs will produce a seedling. In one case (Experiment 81) a few germinating seeds were as much as 3 cm. and several others 2 cm. from the nearest maize-root.

This last result occasioned some doubt as to whether the conclusion previously arrived at (p. 174) that the witchweed seed will only germinate in the presence of a host-root was correct. In order to test this the following experiments were carried out :—

Experiments 112, 113, 114, 115.

13th May, 1912. These four cultures were arranged in the manner already described, but no maize seed was planted in either 112, 114, or 115. A maize seed was planted in the usual way in 113. The results were as follows :—

1912, 3rd June.—Culture 112.—Six witchweed seeds germinated.
1912, 3rd June.—Culture 113.—Maize germination failed. No witchweed seeds germinated.
1912, 3rd June.—Culture 114.—No germination. Soil, etc., replaced and re-examined on 19th June, when still no seeds had germinated.
1912, 3rd June.—Culture 115.—No germination.

As the supply of mature seed was small after June 1912, and was mostly required for other purposes, the results of Experiment 112 have not yet been adequately tested. The conditions were repeated in Experiments 138 and 139, but no germinations were obtained in the absence of a host plant. The details of 139 may be given here :—

1912, 3rd June.—Culture started as described on p. 174, without a maize seed.
1912, 4th July.—No witchweed seeds had germinated. Now added maize seed in usual way.
1912, 23rd July.—Maize plant strong. No germination of witchweed seed. Removed maize plant and planted fresh maize seed.
1912, 12th August.—A few young witchweed seedlings ; many seeds swollen or slightly cracked at micropyle.
1912, 26th August.—Numerous witchweed seedlings.

While the peculiar result of experiment 112 is not yet explained, there is no doubt that germination of the witchweed in the absence of a suitable host-root, if it ever occurs under natural conditions, is rare.

The root of the young seedling, on emerging from the seed-coat, grows directly towards the nearest maize-root, even if it has to turn upwards in order to do so (Experiment 80). The directive influence exercised by the maize-root upon the first root of

the seedling is therefore sufficient to overcome the natural tendency of roots to grow downwards. If the seed lies in contact with the host-root, or very near to it, the root-tip of the parasite immediately forms a bell-shaped swelling (Figs. 1 and 2), which applies itself closely to the surface of the maize-root and gives rise to the first haustorium.* It is to be noted that the swelling begins to form before the tip comes into contact with the main root of the maize, though it may be that contact with the root-hairs supplies the necessary stimulus; also that the swelling in its first stages produces root-hairs.

If, on the other hand, the seed lies at some distance from the host-root, the first root of the seedling becomes much elongated† (Fig. 3) and only forms the haustorium when the contact is established. It is probable that a seed germinating at a considerable distance (say 1-2 cm.) from the nearest host-root never succeeds in forming this haustorium, and therefore does not cause infection. In these cases the elongating root usually assumes a more or less spiral form, as if it lacked a directive influence, such as the maize-root clearly exercises upon seedlings germinating in its immediate vicinity. The food required for the growth which occurs before infection is completed is supplied by the endosperm of the seed, which is gradually absorbed by the cotyledons, and probably also by the upper part of the hypocotyl (Fig. 4).

When the bell-shaped haustorium once becomes applied to the surface of the maize-root, one or more outgrowths quickly arise from the applied surface (Fig. 5 and Stephens *l. c.*, Fig. 6) and penetrate the tissues of the host. The maize plant is now infected, and the only practicable method of killing the witchweed is to kill the maize-root on which it has established itself.

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* This is not a suitable place for the discussion of questions of formal morphology. It may, however, be pointed out here that many authorities (*e.g.*, Goebel, Heinricher, etc.) regard haustoria of this character as organs *sui generis*; others (*e.g.*, W. A. Cannon) consider them to be modified roots. In Striga, as in Krameria (*cf.* Cannon, W. A. Root-habits and Parasitism of *Krameria canescens*, Gray, 1910), the first haustorium of the seedling is a structure produced from certain tissues of the root-apex. While this does not prove conclusively that the haustorium is a modified root, it is nevertheless favourable to that view.

† The elongated region is no doubt a hypocotyl.

Soon after the stages now described, the terminal bud of the stem (Fig. 4) is set free from the cracked seed-coat (Figs. 5, 6), which usually adheres for some time to one of the cotyledons or to the lower part of the stem. The young stem now takes an upward direction (Fig. 6) and grows towards the surface. The rate of this growth varies within wide limits, and is no doubt determined by nutritive conditions, the precise nature of which is obscure. Probably the seedling stem grows very slowly, taking some weeks to reach the surface, when it is deriving its food supply from a very young maize plant; when, on the other hand, the maize plant is already well grown before the infection is established, there is reason to believe that the witchweed seedling grows much more rapidly.

In the following instance the maize plant was almost certainly infected very early in its history ; it grew very slowly and in seven months attained a height of only 6 inches above the ground.

Experiment 46c.

1911, 24th December.—One Hickory King seed planted in pot of naturally infected soil from Koedoespoort, Pretoria.
1912, 24th February.—First witchweed plant appeared above ground.
1912, 27th February.—Second witchweed plant appeared above ground.
1912, 29th February.—Third and fourth witchweed plants appeared above ground.
1912, 5th March.—Fifth witchweed plant appeared above ground.
1912, 6th March.—Sixth witchweed plant appeared above ground.
1912, 8th March.—Seventh witchweed plant appeared above ground.
1912, 15th March.—Eighth witchweed plant appeared above ground.

Culture maintained until 19th June, but no other witchweed plants appeared.

We have, of course, no information as to the dates at which the eight witchweed seeds began to germinate, but from the knowledge furnished by other cultures it is probable that some of them produced seedlings within a week of the germination of the maize. This would give a period of about seven weeks for the subterranean growth of the witchweed. Incidentally it may be noted that this culture shows that a single maize plant may support as many as eight witchweeds and yet remain alive for seven months.

The primary root of the seedling produces a single haustorium. This does not long suffice for the rapidly increasing needs of the

growing stem. New roots arise from the lower part of the stem (Figs. 6, 8), and from these are produced in due course both lateral

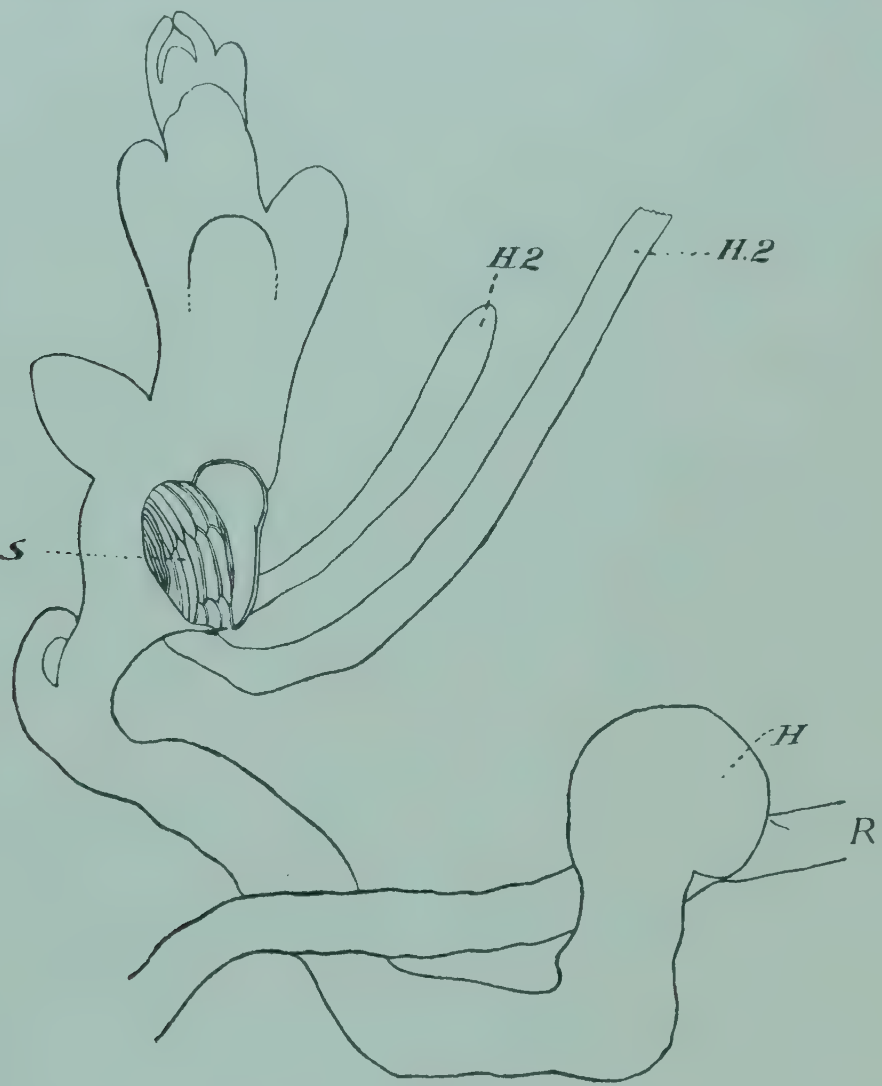

FIG. 8. An older seedling. *H*, Primary haustorium; H_2, A branch which will give rise to a second haustorium; *S*, Seed-coat.

and terminal haustoria,[1] resembling the first one in structure and in function. In this way a single witchweed plant can infect many maize-roots, which need not even belong to the same plant. With this insight into the manner in which the witchweed obtains its food supplies, it is easily realized that a crop of the magnitude of that described above has caused a very severe drain upon the neighbouring maize plants in the course of its growth upwards from the infected roots to the surface of the soil.

The information gained in this study of the germination of the seed has disclosed what may be described as the weak point in the

[1] Stephens. *L. c.*

life-history of the witchweed, *viz.*, the period during which the young seedling is making its way to the host. This period is short, perhaps never exceeding a few days. Any remedial measures that may be effective must be so used as to be available during this period. If infection is to be prevented altogether, these measures must be available throughout the whole period of growth of the maize-roots and at all points which they reach. In most cases this will be impossible for various reasons, some of which will be discussed later. The best that can be hoped for in a soil containing a great quantity of witchweed seed is to keep the maize free from infection during the first month or six weeks of its growth. Later infections do not, as a rule, ruin the crop, and the witchweed plants resulting from them are more easily dealt with by mechanical methods.

The destruction of the witchweed seedling.

The problem, then, is to kill the witchweed seedling before it has found and attached itself to the host. The means adopted must be such as will not also kill the maize. This excludes a number of well-known poisonous substances (*e.g.*, arsenic) which would undoubtedly be effective for the witchweed alone. Other poisons (*e.g.*, carbon bisulphide) which are frequently used on a small scale for similar purposes are useless here on account of the expense. But there are other substances (*e.g.*, copper sulphate), of which quantities which would not be sufficient to injure the maize might nevertheless destroy these delicate witchweed seedlings. Experiments on these lines are now being conducted, and it is hoped that definite results will be obtained in time to be tested in the field during the coming season. At the same time it is obviously undesirable to resort to such a method until all others have failed.

A more economical method would be the use of substances which would, at the same time, assist the growth of the maize and retard or altogether prevent that of the witchweed seedling. The study of such a method has been the principal subject of investigation during the past year.

The growth of a root in the soil depends, amongst other things, upon its powers to absorb fluids from the soil, *i.e.*, soil-water. This

power in turn is determined by the nature and the concentration of the solutions contained within the cells of the root. If, instead of ordinary soil-water, the young roots meet a solution sufficiently concentrated, then the fluid passes out of the root instead of into it, and this means the cessation of the growth of the root, at least for a time. If this abnormal condition can be maintained long enough, the root will be killed. Now we have two roots to consider, *viz.*, the maize and the witchweed. It is possible that the cells of the witchweed root will withstand a higher degree of concentration of the soil-water than the cells of the maize.[1] But even if this is the case, if the concentration of the soil-water is sufficiently high, the extreme delicacy of the first root of the witchweed justifies the hope that it may be killed before it has had time to adapt itself to the new conditions. The more robust maize-root will in the end almost certainly possess a greater power of adapting itself to higher degrees of concentration[2]. Also, it is not improbable that the concentrated solution absorbed by the seed in its early stages of germination may kill the embryo before the root emerges from the seed-coat. And there is a further, if perhaps smaller, possibility that certain substances known to exert a favourable influence upon the growth of the maize, either generally or in particular soils, may prove to have a directly poisonous action upon the seedling of the parasite.

Among common substances which can be used to increase the concentration of the soil-water for the objects above described, the following are the most effective in the order named (those bracketed together being equivalent) :—

1. Potassium citrate.
2. { Magnesium chloride.
   Calcium chloride.
3. { Potassium acetate.
   Sodium chloride.
   Sodium nitrate.
   Potassium nitrate.

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[1] MacDougal, D. T., and Cannon, W. A. *L. c.*

[2] Hill, T. G. Observations on the Osmotic Properties of the Root-hars of certain Marsh Plants. *New Phytologist,* VII (1908).

Of these substances, three, *viz.*, sodium chloride, sodium nitrate, and potassium nitrate,[1] particularly the two last, are known to possess considerable manurial value for maize. But in the case of the nitrate some of its manurial value must be sacrificed if used for the purpose described, for the best effects upon the maize are obtained when it is applied at least a month after sowing [2] ; if it is to interfere successfully with the germination of the witchweed a much earlier application is necessary.

Many laboratory trials of salt and nitrate have been made. The substance was mixed with the soil above the layer of witchweed seed (B_1 in diagram on p. 174), for if applied in the field after the sowing of the maize it will not be possible to place it far beneath the surface. But as long as it is not too far from the place which will afterwards be occupied by the maize-roots, it will sooner or later reach it by diffusion. The following are examples of the results obtained :—

Experiment 52 (control).

1912, 26th February.—Infected soil from Springbok Flats in large pot. Two maize seeds planted.

1912, 4th March.—Maize plants appeared.

1912, 19th March.—Both plants stunted ; leaves discoloured and drooping. Uprooted one plant and found it to be infected with witchweed in many places.

1912, 22nd April.—Two witchweed plants up.

1912, 29th April.—Six witchweed plants up.

1912, 19th June.—Maize plant 18 inches high ; leaves small, discoloured and drooping. Small tassel appearing.

As the necessary temperature could not be maintained longer, the experiment was discontinued.

Experiment 53.

1912, 26th February.—Soil of same sample as in Experiment 52. Two maize seeds planted. 4 grammes sodium chloride (common salt) stirred in among the surface soil.

1912, 4th March.—One maize plant up. (The second seed did not germinate.)

1912, 19th March.—Maize plant much larger and more robust than that of 52 on same date.

1912, 22nd March.—Two grammes potassium nitrate stirred among surface layer of soil.

1912, 22nd April.—One witchweed plant up.

1912, 19th June.—No more witchweed had appeared. Maize plant 3 feet high, robust, forming cob.

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[1] Duggar, J. F. *Southern Field Crops*, New York, 1911.

[2] Duggar. *L. c.* Ingle, H. A. *Manual of Agricultural Chemistry*, London, 1908.

Experiment 54.

1912, 26th February.—Soil of same sample as in 52. Two maize seeds planted.

1912, 4th March.—Both maize plants up. 4 grammes sodium chloride stirred in among surface soil.

1912, 19th March.—Maize plants small, but robust, and apparently healthy. One plant uprooted. Infected by one witchweed seedling only.

1912, 19th June.—No other witchweed plant appeared. Maize plant had not tasselled, but otherwise appeared to be vigorous.

Since the soil used in these three preliminary experiments was obtained from the same sample and was therefore presumably uniformly infected, the results obtained permitted the conclusion that sodium chloride and potassium nitrate are effective in reducing the infection. These results were tested more precisely by cultures arranged as described on p. 174.

Experiment 88.

1912, 3rd May.—One maize seed. 0·5 gramme sodium chloride mixed with the soil B_1 (see p. 174). Witchweed seed from same sample (59a) as that used in Experiments 89, 90, and 91.

1912, 15th May.—Many witchweed seeds entangled in root-hairs of maize. Only one seedling had effected an attachment. Many of these seeds were swollen at the apex. Lower block of soil (B_2) and the witchweed seed were replaced in pot; a new lot of soil (B_1) added above, and a fresh maize seed planted.

1912, 3rd June.—One witchweed seed had germinated. The exposed root of the seedling was brown and shrivelled. No infection.

Experiment 89.

1912, 3rd May.—Conditions as in 88, but only half the quantity of sodium chloride (0·25 gramme) used.

1912, 15th May.—Thirty-four witchweed seeds entangled in maize root-hairs. Two of these had germinated, but in both cases the seedling root was shrivelled and dead. Other seeds were cracked at micropyle. Another maize rootlet was in contact with over 100 witchweed seeds. Two had germinated. The cells of one were plasmolysed; the other was dead. No infection.

Experiment 90 (control).

1912, 3rd May.—Conditions as in 89, but no sodium chloride used.

1912, 15th May.—Very numerous germinations and infections.

Experiment 91 (control).

1912, 3rd May.—Conditions as in 90.

1912, 15th May.—Hundreds of witchweed seeds had germinated.

Similar results were obtained by using nitrate instead of sodium chloride (Experiment 109, etc.).

These experiments justify the conclusions that (1) the substances used to exercise a deterrent effect upon germination, and (2) this effect is produced in the manner suggested (see p. 188), *viz.*, by causing the cells of the young root of the seedling to part with their fluid contents, as a result of which they become "plasmolysed" and later shrivel up. These results are obtained by the use of quantities which do not seriously interfere with the growth of the maize-root. But they give no information as to the period during which the substance, applied under the conditions prevailing in the field, may be expected to be present in sufficient quantity to be effective.

Another possible method of preventing successful germination is based upon the fact that most plants show a preference either for an acid, alkaline, or neutral nutritive medium; and in many cases a plant which grows normally in acid soil is starved or even unable to exist in a soil which is neutral or alkaline. A series of experiments soon showed that an acid medium is favourable to the germination—and perhaps to the maturation also—of the witchweed seed. This fact is indicated in the following experiments, which were, however, arranged for a different purpose.

Experiment 240 (control).

1913, 30th April.—Culture arranged as on p. 174. Witchweed seed from sample 116.
1913, 19th May.—Two germinations only.

Experiment 239.

1913, 30th April.—Conditions as in 240, but 4 grammes of flowers of sulphur mixed with soil.
1913, 19th May.—Soil smelt strongly of sulphur dioxide and therefore was acid. Witchweed germinations more numerous than in any culture previously examined.

(Experiments 237 and 238, in which smaller quantities of sulphur were used, showed similar results.)

An acid medium therefore suits the witchweed, at least in its early stages, and neutral soil is also favourable, though less so than the acid. It was therefore possible that an alkaline medium

would prove unsuitable. A satisfactory test for this was difficult to arrange. The soil can be kept alkaline for any requisite period by watering with weak solutions of alkalies, but this involves the use of a quantity of water sufficient to prevent the witchweed germination. It was therefore necessary to use a substance which in the presence of a small quantity of water will continually produce an alkali. Such a substance is calcium cyanamide. This is a valuable "fertilizer," and is likely to produce a beneficial effect by forcing the growth of the maize.

Calcium cyanamide in presence of water evolves ammonia. It was found by daily testing with phenol-phthalein that 2 grammes of cyanamide mixed with the surface layers of silver sand in an ordinary flowerpot, 6 inches in diameter at the top (Experiment 47), kept the soil alkaline for sixteen days. In order to apply this test it was necessary to water sufficiently to cause a slight drainage. With less water and a more retentive soil the alkalinity would probably be maintained for a longer period than sixteen days. If, therefore, an alkaline medium proved to be harmful to the germinating seeds, a single application of a suitable quantity of cyanamide should enable the maize to pass the first three weeks of its growth without danger of infection. This view was supported by the results of the following experiment:—

Experiment 87.

1912, 3rd May.—One maize seed. 0·5 gramme calcium cyanamide mixed with the soil B_2 (p. 174). Witchweed seed from the same sample (59a) as that used in Experiments 88, 89, 90, 91.

1912, 15th May.—No germination. Soil and witchweed seed replaced and new maize seed planted.

1912, 3rd June.—No germination.

The controls for this experiment (Nos. 90, 91) have already been described (p. 190). Similar results were obtained in other experiments in which the same or smaller quantities of the same substance were used. These seemed to indicate that germination was prevented by the ammonia evolved by the cyanamide.

Owing to a somewhat short supply of mature seed and the limitations of time, it was not possible to investigate further the

two methods now described before the beginning of the 1912-13 maize season. However, the results obtained were sufficient to justify their application on a larger scale in the field. These field-tests will now be described.

Field experiments.

In attempting to apply the results obtained in the laboratory to experiments in the field, we are confronted with certain difficulties. In the laboratory the conditions of the experiment are known and are subject to quantitative control for as long a period as may be necessary. If we attempt to stop germination by adding certain substances to the soil, we can ensure that the substance remains in the soil by regulating the amount of water. This clearly cannot be done in the field, and consequently the amounts of any particular substance used in the laboratory give little indication as to the amounts which should be used in the field. There is also another outstanding difficulty encountered in certain seasons in the field which is easily overcome in the laboratory. It follows from what has been said above (p. 167) that, other things being equal, the young maize plant suffers more than an old plant. It is therefore clear that in any method which may be adopted to retard the germination of the witchweed seed, the growth of the young maize should be as rapid as possible. In the laboratory experiments conditions favouring the growth of the young maize can be maintained. This is not the case in the field. Suppose, for example, it is possible to prevent the germination of the witchweed for a period of thirty days. If the growth of the maize is rapid, it should at the end of that time be past the stage in which infection is followed by the most disastrous consequences. But if the sowing of the maize is followed immediately by a drought, it may grow so slowly that at the end of the month it is still liable to be ruined by a comparatively few infections. Other complications arise from the varying composition of the soil, for a method that is successful for one soil will not necessarily be equally good for soils of different composition. To put down field-experiments without a preceding investigation under

laboratory conditions is to draw a bow at a venture with comparatively little chance of success ; on the other hand, the application of laboratory methods to field-experiments opens up many difficulties, which, in the main, are due to the fact that these methods must be applied to the soil of whose composition and behaviour in the varying conditions prevailing in the open field very little is known.

Under the circumstances described, the amounts of the substances used in the experiments referred to above do not give any definite information as to the quantities that should be used in the field. Since the substances employed (sodium chloride, nitrate, and calcium cyanamide) have been used in maize cultivation for manurial purposes only, it was decided, in the first instance, to apply quantities which experience has shown to be suitable for the requirements of the maize. These quantities will at least not be injurious to the maize, and they should be sufficient to give some indication of their effects upon the germination of the witchweed and of the necessity of employing perhaps larger quantities to secure a better result.

Another disturbing factor that has to be reckoned with is the unequal distribution in the soil of the seeds of the witchweed. Therefore there must be borne in mind the possibility that the absence of witchweed from a particular experimental plot may be due, not to treatment, but to the absence of the witchweed seed. Then, further, the substances used in the experiment are either soluble in water or give rise to soluble products. An exceptionally heavy rain falling after they have been added to the soil must have the effect of diminishing the quantity of these substances in the soil layers which contain the maize-roots. Such a rain is described in the letter from Mr. C. H. Mitchell, which is printed below. The results of the experiments are therefore liable to be disturbed by exceptional conditions of drought or of rain. The latter difficulty may, of course, be usually overcome by fresh applications, which, however, are only possible so long as their cost falls within the limits of the profit on a normal crop. For it must be remembered that so long as the witchweed exists in any quantity in South Africa, there can be no complete and lasting eradication in any one district. Infection by wind-blown seeds it is impossible to prevent so long as

Plan of field experiments.

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8
75 lb. salt added when mealie is sown.	Control.	Same as Plot 1, but sodium nitrate added 14 days later than in Plot 1.	Control.	50 lb. sodium nitrate added when mealie is sown.	Control.	Same as Plot 3, but salt added 14 days later than in Plot 3.	Control.	$37\frac{1}{2}$ lb. salt added when mealie is sown.	Control.	$37\frac{1}{2}$ lb. sodium nitrate added when mealie is sown.	Control.	$37\frac{1}{2}$ lb. calcium cyanamide added when mealie is sown.	Control.	75 lb. salt added when mealie is sown
50 lb. sodium nitrate added when mealie appears above ground.				75 lb. salt added when mealie appears above ground.				$37\frac{1}{2}$ lb. salt added when mealie is sown.		$37\frac{1}{2}$ lb. sodium nitrate added when mealie is sown.		$37\frac{1}{2}$ lb. calcium cyanamide added when mealie is sown.		75 lb. salt added when mealie is sown.
								$37\frac{1}{2}$ lb. salt added when mealie appears above ground.	Control.	$37\frac{1}{2}$ lb. sodium nitrate added when mealie appears above ground.	Control.	$37\frac{1}{2}$ lb. calcium cyanamide added when mealie appears above ground.	Control.	$37\frac{1}{2}$ lb. calcium cyanamide added one month after planting.
	A		B		C		D		E		F		G	
C O N T R O L.														

Each plot $=\frac{1}{2}$ an acre.
Plots 5—8 are divided into two $\frac{1}{4}$ acre patches.
Each strip labelled "Control" (A—G) $=\frac{1}{4}$ acre; it receives no treatment, but mealies are sown on it.

there are seeds to be carried. Therefore the cost of any remedy of economic value must be well within the limits of the profit of a year's crop.

It was intended that these experiments should be laid down on five different farms, and in this connection I have great pleasure in expressing my indebtedness to the following gentlemen for their kind co-operation, *viz.*:—

Mr. C. H. Mitchell (Bushy Vales, Fascadale, Natal).
Mr. A. E. Tidboald (Knapbrooke, Springbok Flats).
Mr. Weir (Koedoespoort, near Pretoria).
Mr. White (Springbok Flats).
Mr. Williams (Springbok Flats).

Owing to the severity of the early drought prevailing on their farms, Mr. White and Mr. Williams decided to postpone the experiments to a more favourable season. Mr. Weir was unable to lay down plots so large as those originally planned. Mr. Mitchell and Mr. Tidboald carried out the experiments completely.

I visited Mr. Tidboald's plot on 15th and 16th April last and that of Mr. Weir on 18th April. In both cases a drought prevailed at the beginning of the season and sowing was late. At Knapbrooke the plots were situated on the reddish loam soil, an approximate analysis of which has been given on p. 175. The following is the record kept by Mr. Tidboald :—

1912, 27th to 30th December.—All plots planted except portions of Nos. 7 and 8, which, on account of the state of the weather on 30th December, were not finished until 3rd January.

Later applications of the substances used were made at the times indicated on the plan. The rainfall during December amounted to 4·24 inches, distributed over twelve days (the falls on 30th and 31st December, respectively, were 0·8 and 0·72 inches). In January the total fall was 3·07 inches, spread over eleven days. On 9th and 13th January, respectively, the measurements were 0·55 and 0·58 inches. These were the only two days on which the falls exceeded

0·5 inch. Amounts of less than 0·5 inch falling within twenty-four hours are negligible in the high temperatures prevailing on the Springbok Flats in January. Therefore the plots were subject to an almost unrelieved drought during January, and consequently the early growth of the maize was very slow—a fact which militated against the success of the experiments.

The results on these plots as seen on 15th and 16th April were as follows :—

PLOTS 1 AND 2—Infection severe, but probably rather less than in the Controls A and B.

PLOTS 3 AND 4—Infection severe ; probably worse than in Plots 1 and 2.

PLOTS 5 AND 6—Infection less severe than in other plots and than in the Controls D, E, and F. The best results were obtained with double application of nitrate in the lower half of Plot 6.

PLOTS 7 AND 8—No clear difference between these and Controls F and G. All badly infected.

At Koedoespoort the crop was more backward than at Knapbrooke and the indications, therefore, less reliable. The results were, perhaps, further complicated by the fact that part of the area covered by the plots had been manured during the previous season. So far as they could be read on 18th April, the results were similar to those described for the Knapbrooke plots. All the controls showed witchweed abundantly and fairly uniformly. Plots 1–5 and 7 and 8 were in no marked respect better than the controls. Plot 6 was superior to the rest in the size and stamina of the maize and showed less witchweed. Both these results were more marked in that half of the plot which had received a double application of the nitrate.

I have been unable to visit the plots at Bushy Vales. Mr. Mitchell has been so good as to send me the following report on the results observed there :—

Fascadale P.O.,
Natal, 24th May, 1913.

Professor H. H. W. PEARSON, Capetown.

DEAR SIR,

I am writing this line to give you the result of experiments with witchweed. I am sorry they have not been more satisfactory.

In the first case it was a very dry season, so that it was quite late before I was able to get the plot ploughed and planted. Then when the crop was nicely up we had that record rain—over 13 inches in less than a week—and that badly damaged the crop with big washes through it. In addition to that, it was not easy to get a large piece of ground uniformly bad with the weed ; as you well know, the weed shows generally in patches, and even badly infected lands are not uniformly bad. When, therefore, I came to take results of the experiments it was, under all the circumstances, no use picking the crop and judging by the weight of mealies from each, as some were far more damaged by the water washes than others. The best I could do was to go carefully over the plots and, allowing for all the various items, judge on the ground as to general results. The result was certainly that sodium nitrate was most successful. Control A was very marked as between Plots 1 and 2, and Plot 6 was ahead of anything near it ; 3 also showed well. As to the other plots, when I had allowed for certain of the field being less infected than other parts of it and for the damage done by the floods, I could see but little result from either the salt or the calcium cyanamide, except that, I should say, the Plots 1 and 2 were better than 5, but I cannot say if that was the result of the salt plus the sodium nitrate, or if it was not a better part of the field.

I am afraid this will not help you in the work, as we should both have liked, but it is not easy testing for this weed in the same way as one can test the result of a fertilizer on a crop. You can generally get a fair sized piece of land of equal value so as to give a fair test for fertilizers, but the patchy nature of this weed is against regular tests and the weather last season was all against us.

Next year I propose to plough and plant this piece of land across the plots, giving it very careful attention, and I should be able to judge better perhaps the second season than the first as to the killing effect of the chemicals used. Certainly sodium nitrate seems worthy of further testing.

Yours faithfully,

C. H. MITCHELL.

The results of these three series of experiments agree fairly well and seem to justify the conclusions that (1) the effect of the nitrate was distinctly beneficial, (2) the mixture of salt and nitrate was less effective, (3) the application of the salt made little difference to the witchweed, and (4) there was no result at all with the cyanamide. The nitrate certainly should be further tested, and it may be that increased quantities both of nitrate and of salt will give proportionally better results.

These results further suggest certain conclusions as to the nature of the action of the nitrate. As was pointed out above, it was expected to act in two ways, *viz.*, to produce (1) a quickening of the early growth of the maize and a consequent shortening of the period during which it is liable to be most seriously injured by the parasite, and (2) retardation of the germination of the witchweed seed. It was expected that the effect of the sodium chloride, if any, would be much less with regard to No. 1, but would be approximately the same as the nitrate for No. 2. We are therefore probably justified in concluding that the slight beneficial effect of the nitrate was due at least mainly to the early stimulation of the maize plant, and that its effect in preventing the germination of the witchweed seed was small. And yet in suitable quantities both the nitrate and the salt do produce this effect. It is therefore probable that the quantities present in the soil were not large enough ; this may be due either to the application of too small quantities or to the leaching out of these substances from the soil before they were able to make their influence felt.

Sodium chloride was employed some years ago at Kentucky in an attempt to save crops of hemp and tobacco from a root parasite whose habits in many respects resemble those of the witchweed.[1] So far as is known, the use of salt was not in this case tried on a large scale. The preliminary trials, however, indicated that with a surface dressing of salt of the amount of two tons per acre none of the seeds of the parasite germinated successfully, but the germination of the hemp seeds was also prevented for a period of three and a half

[1] Fuller. *L. c.*

months, and at the end of that time the soil still contained too much salt to permit of the free growth of the hemp. With half this quantity of salt (about one ton per acre) the infection of the broomrape was very considerably reduced and the germination of the hemp was fairly successful. This tends to confirm the view suggested above that the quantities of salt and nitrate used in the witchweed experiments were not large enough. But in increasing them we incur a double risk, for we may easily use so much as to stop the germination and growth of the maize, and further, the amount necessary to produce the desired effect on the witchweed may be greater than the profit on the crop can stand.

The nature and extent of the investigations having now been described, attention may be drawn to the general question of the cultivation of maize on witchweed-infected land. It is probable that the nitrate and the salt can be used in quantities sufficient to check the germination of the witchweed seed. These quantities must, however, be limited by economic considerations, and it is not probable that these or other similar substances can be made effective throughout the whole period of the life of the maize plant. If infection during the early stages of the maize can be prevented, the crop will be saved. There are still the witchweed plants arising from seeds germinating late in the season to be reckoned with. These injure the maize plant, but will not as a rule prevent it from setting seed. But if they themselves are allowed to set seed a yearly infection of the land takes place. Apart from this, the presence of the witchweed plant in many districts in a wild state and in native maize patches constitutes a lasting source of re-infection. Some have hoped that in the natural course of things the parasite would "wear itself out," and that the problem would be solved by natural agencies. There is nothing impossible in this view, but it expresses a degree of optimism which, in the circumstances, is altogether unwise and unjustifiable. There is not the smallest real reason to hope that the present generation will see a diminution of the pest except as a result of properly designed repressive measures. On the contrary, it is rather to be feared that unless such measures are successfully applied throughout the witchweed area, its ravages will

become greatly extended, and maize cultivation on certain widespread types of soil will become impossible. The problem is therefore one of extreme gravity.

It is therefore not sufficient to save the maize crop. It will, in addition, be necessary to adopt every possible means of preventing witchweed plants from setting seed. This points to the urgent necessity of a more general application of the methods of intensive agriculture to the cultivation of maize. In stating this conclusion it is realized that a large proportion of those who are engaged in the maize industry are confronted with difficulties arising from shortage of labour and other causes. It must nevertheless be urged that there appears to be no reason to hope that the maize districts will ever be free from this pest, unless it is found possible either to obtain labour enough to keep the land clean, *i.e.*, to prevent the witchweed from seedling or to give up the cultivation of the maize on soils which are peculiarly favourable to the witchweed.

A further measure which cannot fail to reduce the rate at which the witchweed is now spreading is the adoption of a system of rotation of crops, as was urged by Mr. Fuller.[1] The maize is the only South African crop over which this parasite has obtained a complete mastery. In fact, there is no other which has yet been seriously injured by it. The ordinary period of a rotation is certainly not long enough to free the land of living seeds, but even if no seeds died within the period, their opportunity of producing a fresh crop would occur once in a period of years instead of annually as at present.

Where land is badly infected, there is one method of eradication which is perfectly satisfactory in all respects, save those of money and time. This, the method of "trapping," has been previously described[2]. If the field is sown with maize and ploughed up a month later, all the witchweed which has germinated in the meantime is destroyed. If this process is repeated often enough the soil will be cleared of witchweed seed. Four or five such crops during two

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[1] Fuller. *L. c.*

[2] Pearson. *L. c.*

successive years would probably reduce the seed, in even a very badly infected field, to such numbers that intensive cultivation in later years would reduce the loss to a minimum. Poor soils would be improved by so much green-manuring. But the cost in many cases at least will be prohibitive. In such cases the land should be used for some crop which does not furnish a favourable host for witchweed.

I am indebted to Mr. J. Burtt-Davy for supplying me with information regarding the distribution of the witchweed; to Mr. I. B. Pole Evans and to Mr. H. J. Vipond for the hospitality of their respective laboratories; and to Miss E. L. Stephens and Miss H. J. Davison, who have assisted me with the experimental work, the greater part of which has been carried out in the Botanical Laboratory of the South African College.

P. S. Since the above was sent to press a letter from Mr. C. H. Mitchell and a paper by Dr. Heinricher ("Einige Bemerkungen zur Rhinantheen Gattung Striga," *Ber. d. D. Ges.*, XXXI, H.5.) have been received. The following extracts from Mr. Mitchell's letter are published, since they bear directly upon the feasibility of using large quantities of salt (see p. 199) to check the growth of the witchweed:—

"Fascadale P. O.,

"Natal, 6th June, 1913.

"There are two points arising from your letter that I wish to refer to. The first is as to the use of salt in large quantities. When the experimental plots were well up I was planting a very late field of mealies, and the plots 1 and 2 (see p. 195) looked so well then that I thought I would like to see for myself what a good dressing of salt would do on a piece of the late field that I knew was bad with witchweed. I told my son therefore, who was in charge of the ploughing, to broadcast salt over the part I knew to be badly infected. This was done, but as it was only for a trial to please myself, the ground was not measured, neither was the salt exactly; on one piece the salt was put on very thickly. This crop is now up and drying off; it is a poor crop, as all our late crops are this year. But the important

point I wish to mention is this: my sons assure me that over the land where the salt was spread broadcast there has been no sign of the witchweed, though in the grass lands near it has shown very freely. I have not made a personal inspection of that land, yet am quite satisfied with the statements made by my sons, as they are very keen."

In the paper cited, Dr. Heinricher questions the accuracy of the statement previously made that the witchweed completes its life-history during a single year. This statement has not been made for witchweed in the wild state, with regard to which the facts are not yet known. For witchweed as a parasite on maize, however, it is undoubtedly true. Apart from the fact that the maize is itself an annual, we have the results of the following experiment (No. 12) which are conclusive:—

1911, August 1st.—Witchweed seeds received from Mr. Claude Fuller (collected by him in Natal in July 1911). Seed mixed with washed and sterilized silver-sand.

1911, " 2nd.—A pot culture prepared as described above (p. 174) but without a maize seed. The soil used was brought from Koedoespoort, Pretoria, and was carefully sterilized before being used.

1911, November 9th.—One Hickory King seed planted.

1911, December 13th.—Maize plant very small.

1911, " 16th.— " " showing leaf discolouration.

1911, " 20th.— " " with only five leaves of which lowest two are withered. Culture examined. Many witchweed seedlings found. Maize plant removed. Soil replaced in pot and watered with Sach's Culture Solution; two maize seeds planted.

1912, February 10th.—One witchweed plant appeared above the soil.

1912, " 13th.—A second witchweed plant appeared.

1912, " 29th.—First witchweed plant in flower.

1912, March 4th.—Flowers withering. Second witchweed plant in flower.

For prudential reasons these plants were not given an opportunity of setting seed. Similar results have been obtained in other experiments, and they place beyond doubt the conclusion that, as a parasite on the maize, the witchweed plant flowers in the same season as that in which the seed producing it germinated.

National Botanic Gardens,
Kirstenbosch.

Notes

PUSA PEDIGREE SANIWAL DAIRY CATTLE: ANNUAL SALE.

At the conclusion of the Meeting of the Board of Agriculture held at Pusa an auction sale of pedigree dairy cows and young male stock was held on the 18th February, 1922. The sale was well attended and most of the stock offered found a ready sale. Rs. 365 for a 2-year old bull was the top price. The cattle were shown in excellent bloom. Mr. Milligan, Agricultural Adviser to the Government of India, in opening the sale pointed out that the Pusa herd had now reached a stage at which the surplus stock exposed for sale were of excellent quality.

When the final accounts have been settled, it is expected that 60 head will average Rs. 150. The stock went all over India, and the distribution of such pedigreed stock throughout the country will be of value in improving dairy herds in India.

Mr. Wynne Sayer acted as auctioneer and managed to dispose of all the animals in 2½ hours. [G. S. Henderson.]

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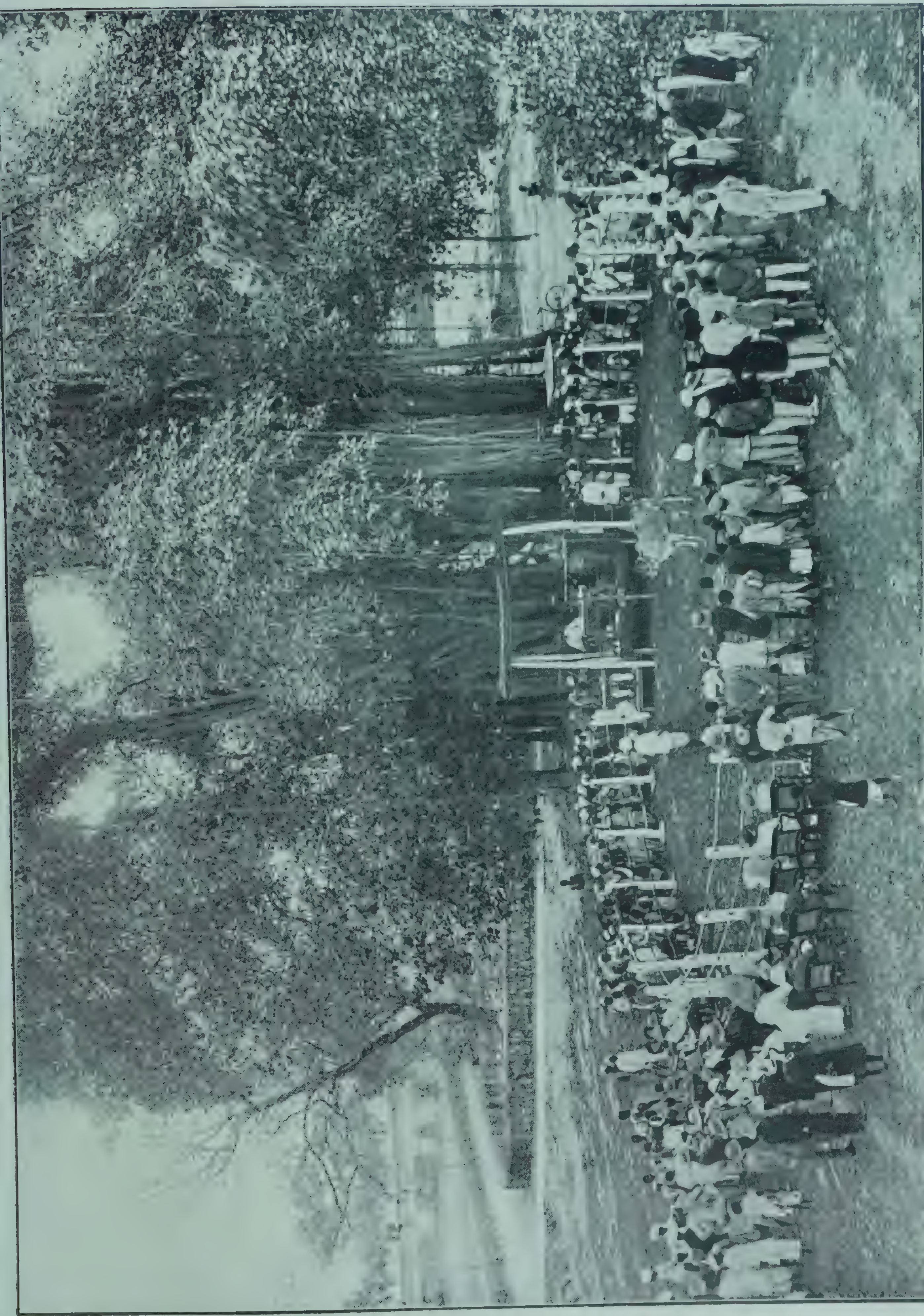
THE CONNECTION BETWEEN SEED-WEIGHT AND LINT-WEIGHT IN COTTON.

The question is often asked as to whether any attempt to increase the weight of lint on the seed of a cotton plant will mean also an increase in the weight of the seeds themselves, or whether it will be accompanied by a diminution of the seed-weight. In the case of Egyptian cotton the question has been answered by the work of Balls, in that of Sea Island cotton by the work of Harland, and in the case of Cambodia cotton by that of Hilson. All these investigators find that, for the cottons with which they have worked, an increase in the weight of lint *does* involve an increase in the weight

PLATE X



of seed, or, in other words, that there is a positive correlation between the two quantities, and they increase or decrease at the same time.

Does this correlation apply generally? We have had the opportunity of testing the point with three pure strains of the cottons of Gujarat, all belonging to the species *Gossypium herbaceum*. These were—

(1) *Goghari E*, a coarse, short staple type with a very high ginning percentage of 48 or over.

(2) *Surtee-Broach* 1 *A* (cylindrical boll type). This is a good quality Surat cotton with a ginning percentage of about 38.

(3) *Surtee-Broach* 1027 *A.L.F.* This represents the best class of Navasari cotton and hence the best staple cotton in Gujarat. Its ginning percentage is about 34.

On testing the question with about one hundred plants of each strain the conclusion of previous workers with other types of cotton was confirmed. In each case there was a positive correlation between weight of seed and weight of lint per seed, the actual figures in each case being as follows:—

	Co-efficient of correlation	Probable error
1. Goghari E	0·729	$\pm$ 0·03
2. Surtee-Broach 1 A	0·46	$\pm$ 0·05
3. Surtee-Broach 1027 A. L. F.	0·52	$\pm$ 0·049

Just as in other types of cotton, therefore, an increase in the weight of lint per seed involves usually an increase in the weight of the seed in the Gujarat *herbaceum* cottons. [M. L. Patel.]

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SCIENTIFIC AND INDUSTRIAL RESEARCH.

The Report of the Committee of the Privy Council for Scientific and Industrial Research, for the year 1920–21 (H.M.

Stationery Office, Price 1*s*.), like its predecessors, provides a most comprehensive and informative review of the entire field of activity of organized research. The textile industry as a whole figures largely in the report, as might be expected, and whilst a summary of the references to the activities in this important sphere may indicate the extent of the ground which is being covered, yet all who are interested in the vast movement of organized research should not fail to read the entire report if only for the purpose of securing comparative information as to activities in respect of the various industries affected, for it is to be remembered that industries are more or less interdependent. The report of the Committee of the Privy Council is a brief statement followed by the more exhaustive report of the Advisory Council.

The Committee points out that, in addition to the limitation of the estimates for the current financial year, they have caused to be prepared, in accordance with Government instructions, preliminary estimates for 1922-23 showing a saving of 20 per cent. of the estimates of the current year. The curtailment of resources, due to financial stringency, is causing both the Committee and the Advisory Council very great anxiety, and the limitation is certain to involve postponement of a certain amount of research work. For the year 1921-22, the estimates were reduced by 17 per cent.

The Committee specially mentions the important work undertaken during the year by the Fuel Research Board, a long series of experiments on the effect of steaming various coals in vertical gas retorts having been completed and a report issued. The expenditure on the Fuel Research Station during 1920-21 was nearly £50,000, whilst elsewhere than at the station the expenditure was £3,683, but over £3,000 was received by way of sale of by-products. The estimates for the coming year show an expenditure, after receipts, of about £55,000.

The number of industrial research associations now approved by the department is twenty-six, and during the year ending 31st March, 1921, grants to associations amounted to £74,557. The balance of the Million Fund then remaining unexpended was £903,205, and of this sum a large percentage has already been earmarked

for associations already formed. The total expenditure on special grants in aid of scientific investigations amounted to £20,912, and provision is made amounting to nearly £9,000 for their continuance during the current financial year. During the academic year 1920-21 one hundred and thirty-two allowances to students were made, seventy grants to research workers to undertake independent research, and forty-three grants to scientific workers to enable them to employ assistance or procure equipment.

The expenditure out of the vote of the department during 1920-21 was £462,650—made up of £373,821 from the Exchequer, £38,022 from interest of the Million Fund, and £58,806 from fees for tests, etc. The full total of expenditure of the department was £552,219.

The report of the Advisory Council covers from 1st August, 1920, to 31st July, 1921. Referring to the financial aspect of the work, it is stated that scientific research is the main, if not the only, source of fresh productivity in industry, and it is only by increased productivity that the world will find a way out of its present economic difficulties. Any reduction in the expenditure by Government on research which is considered by responsible men of science to be needed will react most rapidly, at the point where we are nationally weakest, on the number (not the quality) of competent investigators coming forward. The effect of even a temporary set-back will be long continued and may be lasting. It is certain, the report adds, that unless increased provision is made for the department in future years it will be impossible successfully to carry out the duties of co-ordination laid upon it by the Government in the interests of economy.

Referring to the British Cotton Industry Research Association, the Report says, the Association has begun investigations into the structure of cotton fibre ; the effects of bacteria in causing deterioration of cotton and cotton goods ; the constituents of raw cotton ; and the moisture content and drying of cotton, defective sizing, the variation of tensile strength with twist, measurement of the regularity of yarn, strength of yarns, under a varying stress. Reports on these problems have not yet been issued for want

of adequate laboratory accommodation has considerably hampered the work. The Association, however, is looking forward to the time when its laboratories at the Shirley Institute, Didsbury, will be fully equipped. This Association has undertaken a survey of the literature relating to the cotton industry, and about 2,000 books and pamphlets have been catalogued. The Association has received considerable financial assistance from the trustees of the Cotton Trade War Memorial Fund on the recommendation of the Cotton Reconstruction Board. The Association has received the sum of £50,000, and it is understood that it will receive further contributions of £30,000 per annum for five years. This great accession to its funds, it is pointed out, will afford a good opportunity of demonstrating how organized research on a co-operative basis can be of benefit to all the branches of the industry. [*Journal of the Textile Institute*, November 1921.]

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QUEENSLAND COTTON GROWING : EXTENSION OF THE INDUSTRY.

THE Australian Cotton Growing Association, Limited, has decided to begin operations in Queensland, where cotton has been grown for the past 50 years, having been first introduced at the time of the American Civil War. Cotton growing was then carried on profitably, but later it was abandoned owing to the lack of cheap labour such as was available in the United States.

This season about 900,000 lb. of cotton was produced in Queensland from 1,590 acres, and it is anticipated that a higher average will be attained later when the growers have acquired more experience. Judging by the applications received for seed for next season, it is estimated that 14,000 acres will be planted.

Discussing the prospects of the industry with a representative of "The Times" Sir James Hunter, Agent-General for Queensland, said that the increased cost of production in the United States and the higher prices obtained for cotton had made it possible to carry on the industry in Queensland with white labour. The land in that State cost only one-twentieth the price of cotton land in America.

Long staple cotton.

Mr. W. H. Johnson, F.L.S., has reported that the cotton growing area of the State extended for 1,300 miles along the coast and for 200 miles inland. Dealing with the northern belt, he said that the latitude, climate, and soil were similar to those of the American cotton belt, and being rather nearer the equator were less liable to damage from spring and autumn frosts.

Sir James Hunter added that the Queensland Government had intimated their willingness to make land available for the company. The Hon. Robert Vaughan was now on his way to Australia in connexion with the project. Mr. Armstrong, who had made repeated investigations into cotton growing in America and Egypt, would join Mr. Vaughan early next year. The company had placed an order for a saw gin which would be despatched and erected in time for the treatment of the coming season's crop. A smaller gin of the roller type to deal with the longer staple cotton which had been grown successfully in Queensland was also to be ordered. It was hoped that the longer staple variety would ultimately be the principal variety grown there. Samples of this long staple cotton had been tested by the Imperial Institute and by the Manchester Chamber of Commerce, and they were considered to be almost equal to Egyptian cotton.

Guarantee of 18*d*. per lb.

So far no cotton disease had appeared in Queensland, and every precaution was being taken to prevent the introduction of diseases by importations of infected seed.

"Last year," continued Sir James, "I arranged with the British Cotton Growing Association that it should guarantee 18*d*. per lb. for five years for long staple cotton of the quality that has been submitted to tests in this country, with a limit of £10,000 on the total loss to be borne by the Association. This was done to encourage cotton growing in Queensland, as it was found that farmers who had already engaged in other agricultural operations were disinclined to take up cotton growing without some such

guarantee. The first consignment of cotton under the guarantee scheme has just reached Manchester.

"It is possible that Italians or Maltese will be encouraged to take up cotton growing in the State. Settlers of the former nationality have already proved satisfactory in agricultural districts, being both industrious and well-behaved." [*The Times Trade Supplement*, 1st October, 1921.]

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COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

SHEDDING OF COTTON FLOWER BUD.

A general discussion of the causes of shedding in cotton in which attention is drawn to F. E. Lloyd's work and conclusions. In addition to the structural and environmental causes indicated by him, genetic factors are probably largely responsible for cotton shedding; for example, blasted buds are due to hereditary malformation of pedicels. [*Jour. Heredity*, 1921, **12**, 199–204. O. F. COOK.]

CONTROL OF BOLL WEEVIL.

The destructive power of the cotton boll weevil is increasing as the insect becomes acclimatized. The infestation is spreading rapidly throughout the American cotton-growing area. The Department of Agriculture states that the pest can be controlled by the application of calcium arsenate dust at the right season and in the right way. A proposal to prohibit the planting of cotton for one year has been made. Parasites which prey on the boll weevil are increasing in number and effectiveness. A method of fumigation of seed has been developed, as it is sometimes necessary to transport seed from an infested area. [*Text. Rec.*, 1921, **39**, 52-53. W. WHITTAM.]

Control of pink bollworm.

Fumigation tests have shown that infested seed can be satisfactorily disinfected by carbon bisulphide. Hydrogen cyanide, at atmospheric pressure, has not sufficient penetrating power to be effective to a greater depth than a few inches. The use of arsenical poisons in the field for the control of pink bollworm has yielded only negative results. The larvæ of the pink bollworm are very resistant to water, and have survived forty-eight hours immersion, and larvæ in dry bolls have survived a period of seven or eight days immersion. Careful study of malvaceous plants other than cotton have been made, to determine the possibility of their serving as hosts for the pink bollworm. In no case has the pink bollworm been found to infect any of these plants in Texas. [*Agric. News*, B. W. I, 1921, **20**, 90.]

Microtomy.

A rapid method for cutting microscope sections of cotton yarns and fabrics is described. Briefly it consists in mounting the specimen on a slide with cellulose acetate or nitrate solution applied in layers, stripping from the glass when dry, embedding in paraffin wax and cutting on a Jung microtome. Agar-agar has been found to be the best adhesive for mounting, and sections mounted in this medium will stand repeated applications of alkaline reagents without falling over. [*Jour. Text. Inst.*, 1921, **12**, 99-100. R. S. Willows and A. C. Alexander.]

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SUGGESTED PROGRAMME FOR FARMING IN SOUTH CAROLINA UNDER COTTON BOLL-WEEVIL CONDITIONS.

The Indian Trade Commissioner in London has kindly forwarded to the Indian Central Cotton Committee a copy of the following note by Mr. David R. Coker, of Harts Ville, South Carolina, on a proposed programme of farming in that State to meet cotton boll weevil conditions :—

The march of the boll weevil across the cotton belt has been accompanied by panic and demoralization. Farmers, bankers and merchants, frightened by one or two years of heavy losses, have, in

many cases, curtailed operations and credits to the points where farming was stifled and labour was forced to leave the country to prevent starvation. There are signs that a similar panic may occur in parts of this State unless means are taken to re-assure the people and point out a safe course for agricultural operations under boll weevil conditions. To this end a group of practical farmers and businessmen, in co-operation with the Extension Bureau, have studied the situation in the light of their own experience and that of other States and the accumulated experimental results of Governmental agencies, and beg leave to present the following suggestions and programme as one which will meet the situation, preventing demoralization and enabling our farming and business interests to continue profitable operations.

It is especially important to prevent our people from stampeding into new and untried fields of agriculture in which they will fail for lack of information and experience. Promising new crops should of course be tested and where proved successful should be increased as rapidly as the people gain experience but not faster.

The problem is not so much as to what to do as it is how to re-assure the people and get the information of how to proceed to every farmer, renter and share-cropper in the State. This must be done, if it is done at all, by the larger farmers, merchants, bankers and professional men who should make it their business to reach the isolated farmers and tenants and discuss with them the programme of operations under boll-weevil conditions. The greatest responsibility rests upon the landowners. If they are going to continue to own their lands, they will be obliged to see to it that those who farm them have correct information and closest supervision, for the average farm tenant must have sympathetic and correct instruction and active supervision until he thoroughly learns the new methods of operation.

A few broad principles of operation for the whole State may be suggested :—

First. Destroy immediately all cotton stalks as soon as the crop is gathered. This will prevent the hatching of millions of new

weevils during October. The old weevils do not hibernate until cold weather and the destruction of their food supply will cause them to die before frost. The carrying out of this suggestion at once is imperative and every effort should be made to induce every farmer in the State to do this work at once, for, if only a few do it, it will have little effect in reducing next year's weevil supply.

Second. During the fall and winter destroy all cover in which weevils may be hiding, burning ditch banks and margins of woods and cleaning up around stumps. Fodder and hay stacks should not be allowed to remain near cotton fields.

Third. Cotton should be liberally fertilized with a quick acting fertilizer containing about 50 lb. of available phosphoric acid per acre, ammonia and potash to be used according to the character and relative fertility of the soil. All applications of ammonia should be put down before the middle of June. Over-doses of potash have a tendency to delay maturity. Where the weed grows tall only a small amount of ammonia should be used as it always delays maturity and encourages overgrowth of stalk.

Fourth. Early planting of approved varieties of cotton with plenty of seed. The farmer should save at least three bushels of good seed for each acre he is going to plant. He should plant at least two bushels before April 1 in the lower half of the State and before April 10 in the upper half of the State, reserving a bushel per acre. If a stand is not secured by the first planting he should plant over not later than April 10 in the lower half or April 20 in the upper half. If large quantities of seed are used good stands are usually secured from extra early plantings and the experience is that under boll-weevil conditions the greatest crops are always made from the earliest plantings. If stands are not secured at a comparatively early stage, the land intended for cotton should be put into other crops.

Fifth. Cotton should be left thick in the drill. This distance should vary with the height of the natural growth of the plant, 3″ or 4″ not being too close as a minimum and 8″ or 10″ as a maximum.

Sixth. The question of poisoning for boll weevil is still in the experimental state but your Committee believes that poisoning with calcium arsenate is valuable, especially if done at the proper time and under favourable conditions. Heavy damage from plant lice following dusting with calcium arsenate early last August makes us doubtful as to this treatment when applied at that time. The weevils should also be picked from the plant in the early stages, and as soon as punctured squares are noticed they should be picked up twice per week until mid-summer. Rapid and thorough cultivation at all times should be employed and the crop should be gathered as fast as open to insure a high grade. In no case should more cotton be planted than can be properly handled at all stages and promptly picked by the labour on the farm, for it is the height of folly to plant a crop and let the boll weevil eat it up for lack of attention or allow it to become blue in the fields for lack of picking force.

The experience of many of our best farmers and numerous experiments conducted under the auspices of the Experiment Stations prove that it is absolutely essential in almost all sections to use around 300 lb. per acre of acid phosphate under cotton. In most cases if the amounts applied vary much, either above or below this standard, the crops were less profitable.

Everywhere it must be insisted on that the individual farmer and tenant raise an abundant supply of food and feed and that this food and feed be properly conserved. The man with a crib full of corn and hay, a smoke-house full of meat and molasses, a hundred bushels of sweet potatoes in a storage house and a garden full of vegetables cannot be put out of business by the boll weevil or any other pest.

Storage houses for keeping sweet potatoes should be everywhere constructed, as this is one of the greatest crops we have and one which every farmer can raise.

The note concludes with special suggestions for different tracts of South Carolina.

COTTON EXPERIMENTS IN MESOPOTAMIA.*

The paper describes an experiment carried out with a variety or form of the American "Webber 49," called "Mesopot White." In spite of lack of irrigation, owing to disturbances in the country, 1,250 lb. of seed cotton per acre were obtained over the 80 acres used for the experiment. Other experiments giving promise were carried out with Egyptian cotton. There is now enough seed of Mesopot White available to plant 2,000 acres. The experiments have shown that the industry would provide full-time occupation for Arabs during the summer months; even with irregular treatment, yields equal to the average of Egypt can be obtained; the Arabs can be taught to cultivate cotton intensively as in Egypt; and that cotton growing on a large scale would provide for the prosperity of the country in general. [W. R. in *Jour. Text. Inst.*, 12th December, 1921.]

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CULTIVATION OF PIMA COTTON.†

From the results of field experiments it appears that thorough cross-pollination leads to an increased yield of seed and raw cotton. Bee-keeping near the cotton fields is advocated. [J. C. W. in *Jour. Text. Inst.*, 12th December, 1921.]

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* *Bull. Imp. Inst.*, XIX, pp. 227–229.

† Kearney, T. H. *Jour. Heredity*, XII, pp. 99–101.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE post of Imperial Cotton Specialist in the Imperial Department of Agriculture is abolished with effect from the 9th August, 1921.

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MESSRS. S. C. J. BENNETT AND H. COOPER have been appointed Second Bacteriologist and Pathologist, Imperial Bacteriological Laboratory, Muktesar, respectively.

***

MR. G. F. KEATINGE, C.I.E., I.C.S., Director of Agriculture, Bombay, has been permitted to retire from the Indian Civil Service from the 27th October, 1921.

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MR. GANDA SINGH CHEEMA, Horticulturist to the Government of Bombay, was on privilege leave for 15 days from the 3rd February, 1922.

***

MR. G. EVANS, C.I.E., Director of Agriculture, Bengal, has been appointed to act as Director of Fisheries, Bengal, in addition to his own duties.

***

MR. SAADAT ULLAH KHAN has been appointed Deputy Director of Agriculture, Madras.

***

MR. D. ANANDA RAO, B.Sc., has been appointed Deputy Director of Agriculture, IV Circle, Madras.

***

MR. D. G. MUNRO has been appointed Assistant to the Principal, Professor of Agriculture and Superintendent of the Central Farm, Coimbatore, *vice* Mr. Ananda Rao, transferred.

MESSRS. ANGUS McLEAN, ALEC. A. HENRY, H. T. ROBERTSON AND R. WATSON, who have been appointed to the Indian Agricultural Service, have been posted to Burma as Deputy Directors of Agriculture.

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MR. D. QUINLAN, M.R.C.V.S., Director of the Civil Veterinary Department, Bihar and Orissa, has been granted an extension of furlough for two months.

***

MR. H. W. BLAKE, Agricultural Engineer, Bihar and Orissa, was on leave without pay from the 15th to 28th February, 1922.

***

MR. R. L. SETHI has been appointed Economic Botanist, United Provinces.

***

SARDAR DARSHAN SINGH, M.R.A.C., Deputy Director of Agriculture, Hansi (Punjab), has been granted privilege leave for five months, Maulvi Fateh-ud-din officiating.

***

MR. H. COPLEY, Agricultural Engineer, Central Provinces, on probation, has been confirmed in his appointment.

***

ON return from combined leave, Mr. F. J. Playmen, A.C.G.I., has been reposted as Agricultural Chemist, Central Provinces.

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THE Twelfth Meeting of the Board of Agriculture in India was held at Pusa, under the presidency of Mr. S. Milligan, Agricultural Adviser to the Government of India, from the 13th to 18th February, 1922. There were eleven subjects on the agenda for discussion, and the meeting was attended by 80 members and visitors. A detailed account of the meeting, together with a photograph of the Board, will be issued in the next number of the Journal.

Review

Statistical Supplement to the Final Report of the Nitrogen Products Committee. (Published by H. M. Stationery Office, London, 1921.) Price 1*s*.

In this publication the data previously published have been revised and corrected in the light of the most authentic information which has become available since the publication of the final report.

The tables have, further, been brought up to date by the inclusion of figures for the year 1920.

The publication is of the greatest interest to agriculturists. A striking set of data are those relating to the world's resources in nitrogen products immediately preceding the war and at the present time.

We find that the total productive capacity from all sources has been doubled between the years 1912 and 1920, and amounts now to somewhat over 1·5 million metric tons of nitrogen per annum.

The main increases have been obtained from by-products ammonia (141,000 tons); cyanamide (302,000 tons), and synthetic ammonia (308,000 tons).

It is significant also that 43 per cent. of the world's supply is now derived from fixation processes.

Another aspect to which attention is directed, is the demand for nitrogenous fertilizers, the increased use of which, since the war, is noteworthy.

In the United Kingdom, for example, the average pre-war application of nitrogenous fertilizers amounted to 24,000 tons of nitrogen. In 1919 the actual quantity so used was 58,000 tons.

Similar increases have occurred in other countries. Further, it is estimated by competent authorities that the already very large total consumption of nitrogenous manures in the United States of America will be doubled within the next seven years.

To meet this anticipated demand, chemical research work on nitrogen fixation problems is being vigorously prosecuted both in Europe and in America.

To enable agriculturists to follow closely this race between supply and demand, it would be an undoubted boon if the publication under consideration could be periodically brought up to date to show how the world's nitrogen position is developing.

With regard to the relative merits of the different fixation processes and the prospects of the by-products and Chili industries little can be said, until more definite data concerning the Haber process and its modifications are available.

The present favourable position of German agriculture in the matter of nitrogenous manures deserves comment. The products of the fixation plants in Germany at present yield a large income to the State from direct taxation (amounting roughly to 100 per cent. of the cost price at the works). In spite of this tax the cost of nitrogenous manures in Germany is much lower than in England which has an open market.

These facts might, with advantage, claim the serious attention of the general public. [F. J. W.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. A Handbook of Some South Indian Grasses, by Rai Bahadur K. Ranga Achariyar. Pp. VI+318. (Calcutta : Butterworth & Co.; London : Constable & Co., Ltd.) Price, Rs. 4-8.
2. The Wheat Plant : A Monograph, by J. Percival. Pp. 473. Illustrated. (London : Duckworth.) Price, 63*s*.
3. More Hunting Wasps, by J. H. Fabre. Translated by Alexander Teixeira de Mattos. Pp. 376. (London : Hodder & Stoughton.) Price, 3*s*. 6*d*.
4. The Story of the Fields, by J. H. Fabre. Pp. 271. (London : Hodder & Stoughton.) Price, 8*s*. 6*d*.
5. Beet Sugar. Condensed description of its Manufacture, by F. Murke. Pp. 175. (New York : J. Wiley & Sons.) Price, 15*s*.
6. A Handy Book of Horticulture, by F. C. Hayes. Pp. 225. (London : J. Murray.) Price, 5*s*.
7. Dairy Farming on Arable Land : Five Prize Essays. Pp. 144. (Liverpool : R. Silcock & Sons.)
8. Management of Dairy Plants, by M. Mortensen. Pp. 358. (New York : The Macmillan Co.)
9. Text-book of Land Drainage, by J. A. Jeffery. Pp. 256. (New York : The Macmillan Co.) Price, 10*s*. 6*d*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Reports.

1. Review of Agricultural Operations in India, 1920-21. Price R. 1-4.
2. Report of the Proceedings of the Fourth Entomological Meeting held at Pusa, 7th to 12th February, 1921. Price, Rs. 7-8-0.

THE COPPERSMITH (*XANTHOLÆMA HÆMACEPHALA INDICA*).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 15. THE COPPERSMITH (*XANTHOLÆMA HÆMACEPHALA INDICA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

On the very hottest day of the year, when the brazen sky compels every animal to take advantage cf any piece of grateful shade and the loquacity of even the crow is stilled, a soft, liquid, monotonous and sustained " tonk-tonk-tonk " gives evidence that the Coppersmith does not find the heat too enervating for song. Its note, which may be compared to the distant sound of a smith beating a sheet of metal, whence its popular name of Coppersmith, is sufficiently familiar during the hot weather in almost every garden throughout the Plains of India, but to most of those who hear its call it is indeed a case of " vox et præterea nihil," the owner of the voice being rarely observed unless especially looked for. Not that its appearance is anything to be ashamed of ; on the contrary, it is a most gorgeously coloured little bird, dressed in green and crimson, the details of which will be seen on reference to our Plate.

The Coppersmith is usually referred to in books on birds as the Crimson-breasted Barbet and, as this name implies, belongs to the family of Barbets, which comprises upwards of twenty species of smallish, thick-set, green, fruit-eating birds, with a short strong

bill, rounded wings and ten tail-feathers. We shall probably return to this group later on in connection with the Common Green Barbet (*Thereiceryx zeylanicus*) and in the meanwhile it is sufficient to remark that the Coppersmith may be distinguished by its yellow throat and blackish cheeks from the other species of *Xantholæma*, which are themselves separated from the other Barbets by the second primary being longer than the eighth, the lower tail-coverts green and the rictal bristles long.

In his fascinating book *Some Indian Birds and Acquaintances*, Cunningham has an excellent account of the Coppersmith, too long to quote in full, but from which we take the following extract :—"Coppersmiths are odd little birds, and most fully characteristic of the group to which they belong in their gaudy colouring, harsh, dry plumage, wonderfully tough skin, and insistent vociferation. During periods of settled, sunny weather, the only thing that seems effectually to check their desire to call is a certain degree of cold, but this is so influential that during the course of the variable winter in Calcutta it may safely be assumed that the temperature in the shade stands at or over 70°F. on any day when their call is to be heard. As the thermometer rises above the prohibitive limit they begin to call more and more frequently, until in the height of summer the monotonously metallic ringing of their notes goes on, almost constantly, from dawn to sunset. When preparing to call they usually take up a prominent place in the crown of a tree, often clinging to the side of an upright twig ; and all the time that they cry they go on constantly turning their heads from side to side whilst their throats swell and their whole bodies thrill with the force of their vocal efforts. The movements of the head give rise to a strangely ventriloquial effect, so that the successive sounds might readily be mistaken for the answering notes of two birds instead of the continuous call of one. Towards the end of the hot weather, and during the early part of the rainy season, they cease to cry so incessantly, because the care of their young families takes up too much time to leave them much leisure for any other occupation." To some people the monotonous note, repeated indefinitely like the tick of a clock, is a source of exasperation until they are ready to

exclaim with the apostle, "Alexander the Coppersmith hath wrought me much evil", and in some parts of India which are not cursed with the ear-splitting shrieks of the Hawk Cuckoo, the latter's name of "Brain Fever Bird" is even at times misapplied to the Coppersmith ; but to most people their song is soothing and it is at least constant and consistent and devoid of the exasperating quality of intermittence found in the true Brain Fever Bird.

Like other Barbets, the Coppersmith is a frugivorous bird and seems to confine itself entirely to wild fig fruits, not being known to attack cultivated fruits at all.* The late C. W. Mason examined the stomach-contents of fifteen birds at Pusa and Mr. D'Abreu those of two more at Nagpur, and in all cases nothing but *Ficus* fruits was found to have been eaten. From an agricultural point of view, therefore, this bird is of neutral value.

The nesting season is in the early part of the hot weather, from March to May in Northern India, earlier in Central and Southern India. The nest, if such a term may be used, is placed at the end of a long gallery, which may be from one to five feet in length, either excavated by the parent birds in sound though soft wood of a branch, or more frequently in a branch which is already decayed internally and into which the birds cut, through the harder external shell of the branch, a perfectly circular hole with the edges neatly levelled off inside and outside, this hole being about two inches in diameter and always placed on the underside of the bough. If a ready-made hollow is available it is preferred and appropriated, but if the birds have to excavate a new gallery on their own account, they usually choose a place on the under surface of a slanting dead bough, especially at a point where a side branch has been broken off and the wood softened by the invasion of fungal mycelium. Whilst working, the bird clings to the bark like a woodpecker, with the end of its tail pressed closely against the surface, so as to serve as an

* Mr. C. M. Inglis, however, writes that prior to painting the Plate he carefully studied the bird so as to try to obtain a natural position, and one morning, whilst watching several of them on a guava tree in fruit, he saw them eating voraciously, digging out huge holes in the ripe fruit. There were about half-a-dozen birds hard at it at the same time and they played havoc with the tree. Mr. Inglis has also seen these birds sometimes hawking for termites. [T. B. F.]

additional support whilst it hammers and picks away with its bill at the soft wood, the chips of wood being sometimes hammered directly off but oftener merely loosened by a series of blows and then picked up and thrown away. Both of the parent birds take part in the work of excavation and they can sometimes be heard excavating their holes long after sundown. The eggs are placed at the bottom of the cavity into which they have thus bored, and which they smoothen a good deal interiorly, often a couple of feet below the entrance, and laid merely on the chips produced in the course of the work. Three or (more frequently) four eggs are laid, the egg being on an average 25 mm. long by 17·5 mm. broad, delicate pink when fresh, pure white later, almost cylindrical, tapering somewhat towards one end, but with the ends themselves broad and obtuse. The young birds are much like the adult, but duller in colour and without the crimson and black markings on the head. Occasionally specimens occur in which the green plumage of the adult bird is replaced by yellowish.

The Coppersmith, we regret to say, seems rather an ill-natured little bird and is therefore not adapted to be a desirable inmate of a mixed aviary. He is not social with other birds rather than actively aggressive, but requires plenty of space and must be fed on his natural fruit diet, as *sattu* (pea-meal paste), although eagerly devoured by this bird, is rapidly poisonous to it.

THE BOARD OF AGRICULTURE IN INDIA, FEBRUARY 1922.

TWELFTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

BY

B. C. BURT, M.B.E., B.Sc.,
Secretary, Indian Central Cotton Committee.

THE twelfth meeting of the Board of Agriculture was held at Pusa from February 13th to 18th, 1922, under the presidency of Mr. S. Milligan, Agricultural Adviser to the Government of India.

There was a large attendance of members and visitors, including Mr. G. Anderson, Director of Public Instruction, Punjab; Lieut.-Col. J. Matson, Assistant Controller, Military Dairy Farms; Lieut.-Col. E. D. W. Greig, Director of Medical Research; Major Richards from South Africa; and Mr. G. S. Butler, Manager, Cordite Factory, Nilgiris. Unfortunately neither the Hon'ble Mr. Sarma, Member for Revenue and Agriculture, nor Mr. Hullah were eventually able to attend, although both had hoped to be present.

The first day's proceedings were opened by Mr. Milligan who, after welcoming the members and visitors, referred to the losses which the Board had suffered in the deaths of Messrs. Howlett, Stuart, Chibber and Col. Farmer. He proposed a resolution of sympathy with their relatives which was carried in silence, all members standing.

Before introducing the business of the Board the President referred to the changes which had taken place in its *personnel* since the early days of the Board, and pointed out that the recent meetings

of the Board differed from their predecessors chiefly in the optimistic attitude adopted towards the problems which confronted them. In 1905 the Agricultural Department stood on the threshold of its career, and the early meetings of the Board of Agriculture reflected the stupendous character of the task which lay before them. With a record of many problems successfully solved, of many improvements actually introduced into cultivating practice, the Agricultural Departments and the Board of Agriculture could now approach the problems before them with a spirit of confidence, particularly as they could now point to students from their Agricultural Colleges holding posts in the Indian Agricultural Service. It was no longer necessary to discuss the problem of "How to get in touch with the cultivator." The Indian ryot had shown that, far from being unapproachable, his conservatism is merely that of any sound farmer all the world over. The present problem was how to find him the necessary means to finance improvement.

After referring to the recent additions to the Indian Agricultural Service and the Indian Civil Veterinary Department and to the formation of the Central Cotton Committee, Mr. Milligan laid emphasis on the necessity for Provincial Boards of Agriculture, Agricultural Associations, Central and Provincial Cotton Committees and other similar bodies constantly keeping before the public the need for research work. The future of agricultural progress in India depends entirely on continuity of research and investigations; without these the Agricultural Departments would soon exhaust their useful propaganda and find themselves back where they were in the year 1905. He paid a tribute to the press of India for their great and influential support for the Agricultural Departments, especially during the early days when there were signs of the public becoming impatient for results.

On the conclusion of the President's speech the Board proceeded to the appointment of Committees for discussion of the various subjects, and then passed to the consideration of the *first subject* on the agenda—*agricultural middle schools.*

An interesting discussion took place which showed that experience in different provinces varies considerably. In the

Central Provinces the type of school contemplated by the Simla Conference had not been found a success. On the other hand such schools have been very successful in some parts of the Bombay Presidency, but not in Sind. Experience in Bengal showed that, there too, modification was necessary. In the United Provinces, on the other hand, there is an obvious demand for purely agricultural vocational school to take the place of the vernacular course of the Agricultural College.

Mr. Anderson, Director of Public Instruction, Punjab, gave an extremely interesting account of the system of teaching agriculture in rural middle schools which is now being developed in that province. At present 30 such schools were at work and 5,000 boys were affected. It was finally resolved :—

(1) " That this Board endorses Resolution No. XIII (2) of the Board of Agriculture which met at Poona in 1917 that, whatever expenditure may be undertaken in connection with general, rural or definitely agricultural education, there should be no resulting diminution in, or limitation of, the funds or staff that are necessary for the maintenance and progressive development of the research and demonstration work which are the main functions of the Agricultural Department."

(2) " That while maintaining the position taken at the Board of Agriculture in 1917, the Board is of opinion that the agricultural middle schools there suggested do not, by any means, exhaust the methods of agricultural education which can be suitably applied, and invites Local Governments to consider carefully the schemes which are being developed in the Punjab and elsewhere, and would urge experiment as to the methods most suitable for the very varying conditions in different parts of the country."

The second and third days were devoted to meetings of Committees and to a visit to the Pusa breeding herds where Mr. Henderson explained the work in progress and the results which had been achieved. A demonstration of various motor tractors and implements was also given in an adjoining field. Organized parties were also taken round the botanical area throughout the week, and arrangements were made for the

members and visitors to see work of interest in the various laboratories.

On the fourth day the Board resumed its full meeting, taking up first the discussion on *Subject II—The line of demarcation between Agriculture and Industries as affecting the work of the departments concerned.*

The subject was thoroughly examined by a strong Committee under the presidency of Dr. Coleman, and their report was accepted by the Board with the formal resolution :—

" That in the opinion of this Board it is highly undesirable at present to attempt to draw any definite line between the spheres of activity of the Departments of Industries and the Departments of Agriculture."

In discussion it was pointed out that industries and agriculture are now transferred subjects and that the definition of the functions of these departments lies with the Ministers concerned ; that in several provinces Boards of Agriculture and Industries had been appointed, and also Development Boards which were better suited than the Board of Agriculture to co-ordinate work. The Committee's report laid stress, however, on the designing and testing of improved agricultural implements as an important duty of the Agricultural Department. The Committee most emphatically dissented from the views expressed in the Industrial Commission's report that agricultural engineering should be placed under the control of the Department of Industries, and found themselves in complete agreement with the resolution passed by the Board of Agriculture of 1919.

The Board then passed to a consideration of the report of the Committee appointed to consider the *proposal to prohibit the export of certain manures from India* (*Subject III*). The majority of the Committee did not agree with the recommendations of the previous Board and considered that in the light of the further information now before them it would be unwise, at the present time, to advocate an export duty on oil-seeds and oil-cakes ; as not only would such a tax cause serious trade dislocations but would also react unfairly on the producer. The Committee recognized the

great importance of preventing the drain of phosphates from India but they were of the opinion that the present conditions preclude the possibility of total prohibition and that any export duty should be imposed with extreme caution.

Mr. Freke, Officiating Director-General of Commercial Intelligence, placed before the Board the present statistical position and showed how the Committee, on the evidence now before it, had no alternative but to reject the recommendations of the previous Board. The Madras representatives urged that while the recommendations of the previous Board were subject to the criticism that they were made on insufficient information, the present Committee's proposals were equally open to objection as going too far in the opposite direction, again without the necessary information, and urged that a constructive policy was necessary.

A spirited discussion followed from which it was evident that the general opinion of the Board was that the question of the export of oil-seeds was on a different footing from the export of phosphates. It was, therefore, decided to discuss these subjects separately, and the portion of the Committee's report dealing with oil-seeds, oil-cakes and ammonium sulphate was accepted as it stood by a large majority.

The Board then resumed discussion as to the measures necessary to preserve Indian supplies of phosphates. It was felt that the Board was not in a position to frame a constructive policy on the information before it, and the following resolution was finally adopted by a large majority :—

" That without expressing an opinion on the portion of the Committee's report dealing with phosphatic manures, the Board is of opinion that, on the evidence before it, it is doubtful whether the method of prohibition or restriction of export of bones, fish manure and other phosphatic manures would achieve the end desired ; but it is nevertheless of opinion that the retention of its manurial resources, specially of phosphates, is of vital importance to the future of the country, and that it is essential that a constructive policy should be framed which would lead to this end, and it therefore requests

the Government of India to appoint a small Committee of about five members to consider the question from this point of view and suggest a constructive policy which will lead to the results desired."

The Board then proceeded to *Subject IV, viz.*, the consideration of the resolution passed by the last Sectional Meeting of Chemists and Bacteriologists regarding *measures to be adopted to secure continuity of field experiments of a permanent nature*, which read as follows :—

"That permanent field experiments, such as manurial experiments or any experiments carried out in relation to soil fertility, should before initiation be submitted for consideration by a Committee consisting of the Deputy Director, the Agricultural Chemist and the Bacteriologist. When once initiated such experiments should not be altered or discontinued without the sanction of such a Committee."

The general opinion of the Board was that no competent man laying down experiments can share responsibility with a Committee, and that no officer should be asked to continue experiments when he was no longer convinced of their usefulness. In any case if a Committee were desirable it should not be limited to three officers, and it would appear that the guidance of policy in starting experiments should be in the hands of the Director of the department. A resolution that the Board did not endorse the recommendation of the Chemists' Meeting was carried by a very large majority.

Subject V—Further discussion on measures regarding famine relief— was very largely a discussion on certain details involved by the recommendations of the previous Board with particular reference to the appointment of a Famine Commission. With the permission of the President the terms of reference were somewhat extended, and in their report the Committee examined the steps which a Famine Commission, if appointed, might suggest in order to ensure a sufficiency of foodstuffs even in the event of two successive monsoon failures. The Committee held that stoppage or restriction of the export of food grains from India was inadvisable save in the most

exceptional circumstances and might indeed lead to results the very opposite to those which they were designed to produce.

They also pointed out that the recommendations of the previous Board so thoroughly covered the steps which might suggest themselves to the proposed Famine Commission that if effect were given to those resolutions the necessity for a Commission would not arise. The Committee, however, found that in many provinces no action whatever had been taken on the recommendations in question and in no province had effect been given to all of them. They, therefore, urged that all Local Governments and Administrations should be asked to give effect to the resolutions of the Board of Agriculture of 1919 in respect of famine protection, and suggested that a Standing Committee of the Government of India might be appointed to see that this was done. It was pointed out that, despite the new provincial autonomy, the Government of India was closely concerned in any serious famine, as not only might it have to come to the aid of a particular province, but provinces were interdependent as regards food supply and the failure of one province to take adequate action might prejudicially affect others.

The discussion in the full Board emphasized the fact that the whole question of famine relief turned on increasing the exportable surplus of food grains in a normal year, as only by this method could the necessary food reserve be produced. Some speakers held that this surplus was rapidly declining, and this would clearly be disastrous in a country subject to the vagaries of a variable rainfall. The view that the best method of meeting famine was to make the country famine-proof had been repeatedly urged in the past, but had too often been assumed to refer to the extension of irrigation. Dr. Mann pointed cut that in one of the Deccan districts if every scheme suggested by the Irrigation Commission were developed in full and if the well-irrigated area were doubled, even then only 6 per cent. of the cultivated area would be irrigable. It was, therefore, essential that such land should produce more in a normal year, and they should further so prepare for famine that the land would be better able to utilize scanty rainfall. To make the country

famine-proof money was needed, and it was considered that Provincial Governments should be allowed to spend a portion of their Famine Insurance Fund, at present reserved almost entirely for famine relief, on improvements which would prevent famine.

The report of the Committee was unanimously accepted by the Board.

The report of the Committee on *Subject VI—The manufacture of nitrogen fixation products in India*—was introduced by Dr. Harrison. The Committee found that the total imports of nitrogen products were at present small and that there had been no great increase over pre-war figures. Ammonium sulphate was actually produced in the country and in 1920 India *exported* 6,780 tons. There seemed no prospect of an immediate increase in demand in the future, but, on the other hand, there was evidence that certain demands were likely to decrease. Whilst there would always be a limited demand for special crops, the cost per unit of nitrogen was too high for the ordinary ryot, and it appeared that the price must fall even below pre-war figures before these manures could profitably be applied to ordinary crops. The cost of production was, therefore, important. It was unlikely that India could produce nitrogen fixation products cheaper than Norway, Sweden, Germany and America. The Committee, therefore, did not feel that they could support any proposal for Government action in the direction of manufacture except in connection with ordnance factories for nitrogen products whose producing capacity must necessarily be in excess of military requirements in times of peace. This excess could be used to give some indication of the limiting unit price which would make this fertilizer attractive to the Indian cultivator.

Attention was also drawn to the recent statement of the Chairman of the British Sulphate of Ammonia Federation, that the capacity for producing nitrogen in the world to-day is far in excess of the possibilities of immediate consumption.

The importance of railway freight on manures was emphasized. Such freights at present are excessive, and it is cheaper to import such manures from the Continent by sea than to rail them from say, Peshawar to Coimbatore.

The report of the Committee was unanimously accepted by the Board.

The fifth day's meeting was largely devoted to the discussion of the report of the two Committees appointed to consider the subjects connected with *cattle-breeding* (*Subject VII*). Lieut.-Colonel Matson, Chairman of the Committee on dairy cattle, in introducing the report of the Committee, pointed out how extremely backward India was in regard to work for the improvement of live stock. Whilst the cotton industry, jute industry, wheat, sugar and rice had all received detailed and co-ordinated attention with substantial benefit to the people concerned, only a section of the agricultural population had been benefitted. The cattle question was of universal importance, as every cultivator is an owner of cattle and dependent essentially on cattle for his livelihood, whilst every urban dweller was a consumer or a would-be consumer of milk. Yet little had been done for the producer of cattle or of milk. Thousands of cultivators engaged on mixed farming at present keep buffaloes to produce milk, and separately cows to breed oxen for the plough, thus burdening their food supply with the maintenance of two females where one should suffice. He pointed to the great need for scientific advice and teaching in matters pertaining to the dairy industry and also the great lack of co-ordination of efforts. His Committee had, therefore, proposed the formation of a Central Cattle Bureau or Board and urged the establishment, with the least delay, of at least one teaching institution for dairy work.

The Board then proceeded to the discussion of the resolution recommending the immediate establishment of a dairy school at Lucknow as already sanctioned by the Secretary of State.

In reply to questions it was explained that the teaching at the Lucknow school would be entirely technical and in English. It was proposed that it should be open to all suitable candidates for whom there was room, and that short practical courses should be given for dairy farmers, and a longer course corresponding to the National Diploma of Dairying which would probably be taken by graduates. The actual curriculum, it was suggested, was a matter for the proposed Cattle Board. The resolution was carried unanimously.

The Board then passed on to the discussion of the second resolution :—

"That the Board recommends the constitution of a Central Cattle Board composed of representatives of the Provincial Governments and Indian States assisted by certain officers serving under the Government of India and under the presidentship of the Agricultural Adviser to the Government of India."

Several speakers urged the necessity of adequate provincial representation on the Central Cattle Board and that it must be a responsible body including the men who would have the carrying out of its policy. After considerable discussion on details the resolution was carried unanimously.

After further discussion on the functions suggested by the Committee for the Central Cattle Board, the report of the Committee was accepted by the Board with certain minor amendments.

Dr. Clouston then introduced the report of the second Committee appointed to deal with cattle-breeding. The terms of reference were (*a*) how the bulls at the various Government cattle farms can be utilized to the best advantage ; in particular (*b*) what is the next stage after the breed had been properly fixed on the breeding farm ; (*c*) can the various small district farms under the Agricultural Department be utilized as centres of demonstration and breeding ? The Committee in their report laid great stress on the encouraging of cattle-breeding by private enterprise and put forward for the consideration of the Board two specific resolutions in respect to organization.

Mr. Sampson moved the following resolution :—

"That this Board is of opinion that, in order to bring animal husbandry in line with the other activities of the department, a live-stock expert should be appointed in those provinces in which that has not already been done."

The discussion largely turned on an amendment that the live-stock expert should be appointed to the Department of Agriculture. Many speakers emphasized the necessity of live-stock work being under the control of the Agricultural Department. Other speakers considered that in several provinces successful work was being

done by the Civil Veterinary Department and that this should not be interfered with. In 1916 the Board of Agriculture had recommended that the question of the control of animal husbandry should be decided by each province with reference to the particular problems involved and the nature of the agricultural and veterinary organizations that may be in existence or contemplated.

A number of speakers emphasized the fact that stock-breeding could not be separated from general agriculture, and although several speakers felt that it was inadvisable to attempt to lay down any short line of demarcation between the works of two departments, the general opinion of the Board was that live-stock officers should be under the Departments of Agriculture and the amendment was carried by a large majority.

The Board then proceeded to the discussion of the second resolution " that animal husbandry should form an important part of the district work of the Agricultural Department, and that the existing organization of the department should be utilized to the fullest extent to this end."

After a short discussion on the wording of the resolution which was finally amended to read as above the resolution was unanimously carried.

On the motion that the report of the Committee be accepted, considerable discussion took place as to the best method of utilizing the bulls from Government breeding farms which largely brought out the varying conditions in different provinces. It was also pointed out that in the issue of improved bulls care must be taken that the animals are suitable to the existing conditions of fodder supply. Not only was it essential not to introduce too big a type, but it was necessary that the Agricultural Department should keep in close touch with the matter so that they could detect, before it was too late, cases of stock produced from Government farm bulls which were not hardy. It was possible that bulls on Government farms, through good keep, might become less hardy and that this might extend to their progeny.

The Report of the Committee was accepted unanimously.

The Board then proceeded to the discussion of the report of the Committee on *Subject VIII—Motor tractor cultivation. For what particular purposes motor tractors may prove useful in India and the best means for arriving at suitable types of both tractors and implements for the various requirements.*

The Committee considered that, as there are only a limited number of tractors at present in use in India, the data available on the subject are insufficient to warrant any statement as to the tracts in which and the extent to which tractors could be economically used in Indian agriculture.

Mr. Wood, in introducing the Committee's report, said that the Committee were divided in their opinion. Some considered that more investigation was required before the use of tractors could be recommended in India. Others felt that the possibilities of tractors in India did not justify the Agricultural Departments spending time and energy on the subject.

Mr. Henderson gave the Board details of the tractor trials which it had been proposed to hold in India and showed how with the present financial stringency this was not possible on account of the great expense.

Various speakers gave instances of the successful utilization of tractors to special problems. Others pointed out that the great difficulty experienced in getting spare parts was at present a very grave defect in the selling organization and made Agricultural Departments hesitate to recommend tractors. The Committee's suggestions for making the most of our existing resources by the interchange of information were approved and the report was unanimously accepted.

Subject IX—Movement of nitrates in soils. The report of the Committee was then introduced by the Chairman, Mr. Carpenter, who said that the Committee emphasized the importance of the need for the study of the formation, accumulation and movement of available nitrogen in soils. They recognized that the supply of available nitrogen at the growing points of the plants' roots at the proper time is a great factor in bringing about increased crop bearing capacity. Various speakers laid before the Board some interesting results of

work at present in progress on nitrogen movements. Many speakers also gave instances of problems which had come to their notice in the course of experimental cultivation which showed the need for further work on this subject.

The Board unanimously accepted the report of the Committee which recommended that the question should be further examined at the appropriate sectional meetings of the Board. Many speakers also emphasized the desirability of the Board devoting more time in future to the discussion of technical subjects of this nature as distinct from questions of policy ; the necessity for constant research was again emphasized. It was pointed out that in England, even during the present trade slump, many trade organizations were devoting large sums to research work for their particular industries, as they realized that they would have to meet new and more severe competition in the future and were determined to meet this by increased technical efficiency.

The last day's proceedings opened with the discussion of *Subject X—The improvement of the potato crop, with special reference to the seed supply for the plains.*

The report of the Committee included a brief survey of the conditions as regards the supply of seed for planting in the plains in different provinces. It was shown that nearly all provinces were largely dependent on hill seed, but the supply was by no means satisfactory and that much can be done to improve it. Instances were given of the successful raising of seedling potatoes in the Punjab hills and Mysore. Attention was drawn to the great need of further study of the storage problem in view of the almost prohibitive cost of supplying some areas entirely with hill seed.

The Director of Agriculture, Bombay, laid before the Committee, and subsequently the Board, the importance of the importation of Italian potatoes for sowing into Bombay, and showed that potato cultivation in the Deccan was almost dependent on this importation which is carried on with considerable difficulty as it is not very remunerative.

He urged the suspension of the notification under the Destructive Insects and Pests Act for a period of years to enable the present

difficulty to be got over. This point raised considerable discussion in the Board. On the one hand it was urged that there is no evidence to show that the wart disease of potatoes is prevalent in South Italy and that it is impossible to inspect wholesale imports, whilst certificates of freedom from the disease would be difficult to obtain. On the other hand it was urged that the risk of introducing wart disease into India was too serious to justify relaxing the Pests Act, particularly as cases were known where the introduction of wart disease into other countries had not been detected for several years. Finally the Board, by a majority, accepted the majority report of the Committee that—

"In view of the seriousness of wart disease the production of certificates required with potatoes imported into British India should be enforced, but that to help the import of seed potatoes required in the Bombay Deccan from Italy, the Ministry of Agriculture in Italy should be asked to facilitate the issue of official certificates to consignors in Naples."

During the discussion of the general problems connected with potato cultivation the importance of its extension as adding to the food supply of the country was emphasized by a number of speakers, and it was clearly shown that the present high price of sets for planting, by greatly increasing the cost of production, acts as a distinct deterrent to the extension of cultivation. It was, therefore, urged that all possible steps should be taken to improve the supply of disease-free sets for planting by better organization of hill cultivation and of the supply of hill seed, by the introduction of superior and disease-resistant varieties for cultivation in the hills and by the production of seedlings both in the hills and where possible in the plains.

The Board then proceeded to *Subject XI—Whether biennial Sectional Meetings of* (1) *Botanists,* (2) *Agriculturists and Agricultural Engineers are advisable.*

The President explained that the subject had been brought up for discussion, because, while touring in the provinces, he found that some officers, who did not usually come to the Board meetings, had expressed a desire for such sectional meetings. He explained that,

so far as meetings of agriculturists and agricultural engineers were concerned, not only would this mean considerable dislocation of work in the provinces, but there would be some difficulty in arranging for accommodation of a large number of officers at Pusa in future.

After considerable discussion it was found that the general opinion of the Board was that it was not practicable to add to the number of sectional meetings—not only on account of the difficulty of officers being away from their provinces, but on the ground of expense. It was urged that the necessary opportunity for discussion of technical subjects by groups of officers interested could be arranged by a modification of the constitution of the Board. The Board would probably be less occupied in future with administrative questions, and time could be found for meetings of officers engaged on work of particular crops or engaged on special problems.

The President then closed the proceedings of the twelfth meeting of the Board of Agriculture. The modification in the time table was greatly appreciated as it had been felt by many in the past that formal meetings left too little time for informal discussions and for the study of work in progress. Many members took advantage of the opportunity to attend the auction sale of pedigree cattle from the Pusa herds which took place on the afternoon of the 18th.

A METHOD OF RICE SELECTION IN ASSAM.

BY

S. K. MITRA, M.Sc., Ph.D.,

Economic Botanist to the Government of Assam.

From time immemorial no other crops have received so much attention in the development of civilization as the cereals. The ancients took special care in sowing and harvesting such crops at the right time, otherwise they were found to degenerate in quality and yield. History shows that the Egyptians and the Chinese and later on the Greeks and Romans selected the best ears of wheat and oats in order to keep the varieties pure from the influx of degenerate types that arose out of the old material.

It may be a little surprising to many to know that a similar system of selection of paddy ears is in vogue among the cultivators of Assam. The unlettered Assamese have found out, through long experience, like their Western and Eastern brethren, that a careful selection of paddy is the best means of keeping up the purity and characteristic qualities of the desired varieties, and they have been continuing a process which has up to the present escaped the notice of the experts.

It is a common custom among the peasants in the Assam valley to harvest the rice crop in small bundles called *mutee* which means a handful of sheaves cut and tied separately. Besides, it is also the usual practice in Upper Assam to store the harvested paddy in the straw in the granary.

Usually two methods of selection are adopted by the people :—

(1) The most careful cultivators select a plot in the field suitable for seed purposes. In this case the farmers

depend for results on their good judgment. Extreme conditions, such as areas too dry or too wet, are always avoided. Uniform ripening and medium size of straw and ears are specially noted. The bundle of sheaves harvested from selected plots is kept separate for a time until the pressure of work in the fields is over, when the *mutees* are opened and selected by hand.

(2) In the second case, no field selection is done. When the proper season comes round, the rice is harvested in *mutees* and is temporarily stored. The *mutees*, when opportunity arises, are then taken out and selected by hand.

The method of selection from the *mutee* is very simple. The operator unties the *mutee* or bundle, grasps the top of the ears with the left hand and shakes them slowly. This causes the small ears to fall to the ground. He then grasps the other end of the *mutee* with the right hand and after again shaking the same, he lays it flat on the ground. All the small, poor and abnormal ears are then removed. The sound ears that are left are kept separately, threshed and packed in specially made bamboo baskets lined with straw called *tom* or *topa*. These baskets are then kept hanging from the ceiling of the house. Some of the cultivators prefer to hang the baskets in the kitchen or over the open fireplace where water is boiled. This latter practice keeps the seeds free from insect and fungus pests.

The seed baskets are taken down when the sowing season begins and are used as desired. In my opinion, this process of field and hand selection is perhaps the best and easiest method that every cultivator can follow so as to keep up the purity and quality of the cultivated paddies of the desirable types. That it exists among the Assamese proves how much the cultivator of this tract values good seed for his paddy crop.

CATTLE STOCK AND FODDER FAMINES IN HISSAR.

BY

R. BRANFORD, M.R.C.V.S.,

Superintendent, Government Cattle Farm, Hissar.

THE writer having been connected with the Government Cattle Farm at Hissar since April 1911 to date, has made the following somewhat detached observations regarding cattle and fodder famines, some of which may be of interest to stock-owners.

The period 1911 to 1921, as regards rainfall, was unfortunate compared with the previous ten years. The years 1911, 1912, 1913, 1918 and 1919 were below average as regards rainfall, and were bad years for grass and for fodder crops. The years 1915 and 1920 were complete failures as regards grazing, and both *rabi* and *kharif* crops. The year from April 1st, 1920, to March 31st, 1921, produced the smallest rainfall of which this farm has any record (some 3 inches less than the great famine year of 1899-1900). The total was only 5·74 inches.

GRAZING FROM BUSHES AND SCRUB JUNGLE.

To what extent can cattle exist on it? The value of purely *barani* bush jungle for grazing purposes is, I think, much exaggerated. I have heard grazing in the Hissar Bir in famine times described as good, when there was absolutely nothing by way of grass; presumably the scrub was referred to. The average cow, if left to that unaided, would die of starvation in a few days.

The common scrub jungle bushes in the Hissar District are Jhal (*Salvadora oleoides*), Karil locally known as Khair (*Capparis aphylla*), Jand (*Prosopis spicigera*), Wild Bher (*Zizyphus nummularia*) and, in low lying places, Kikar (*Acacia arabica*). Except *kikar*, the other bushes do not appear to be much affected by drought. From August 4th, 1920, to June 7th, 1921, the total rainfall recorded here was $\frac{1}{10}$ inch only, but even in the driest spots these bushes came into leaf, flower and fruit very much as usual. Cattle, however, appear to me to relish these bushes much more in good years than in bad and seem to graze off them more. At the close of a famine year when all grasses are absolutely exhausted, it is only with difficulty that cattle will move into the Bir at all. They prefer to stand about round their lines, and wait for the next feed, even if only on half rations, rather than move about to graze scrub. Certainly the great majority of local cattle would die if left to this sort of grazing alone. As regards *jhal* and *khair*, these are much more grazed when in flower and fruit in April and May than at other times. *Kikar* and *jand* do not usually have much leaf in reach of cattle. The pods of these trees are eagerly picked up by cattle when they drop off in the spring. *Kikars* at any distance from canals usually have little or no leaf in times of drought; what they have and that of *jand* also is cut off in great quantity by graziers and the twigs are then readily grazed by cattle. In the neighbourhood of canals, the *kikar* carries more foliage, and is always in famine years most unmercifully lopped.

The leaves of *shisham* (*Dalbergia latifolia*) trees and of all the fig tribe (*pipal*, etc.) are readily eaten by cattle, but for all practical purposes none of these trees grows in this district without added water in some form or other and they are not available as fodder in *barani* tracts. There are, however, large numbers of *shisham* on canal banks. Wherever there are canals the trees are always under heavy foliage and seed in May and June, and in my opinion form a very valuable reserve of fodder wherever they exist. After lopping, new twigs are very rapidly formed, if the trees have sufficient water. Generally *shishams* can be lopped twice in one hot weather. Cattle are very fond of the foliage

and eat it readily even when good grass grazing is available. It is impossible to grow *shisham* at all in this district unless the young trees are protected until they have grown out of the reach of cattle.

It has always been my custom here in times of scarcity to lop *shisham* pretty extensively for stock : but during the season just past, owing to shortage of canal water and consequently of other green fodder, I fed *shisham* foliage much more extensively than ever before, with, on the whole, very encouraging results.

In one particular instance from June 16th to July 14th I fed *shisham* leaves to a herd of 560 dry cows. Owing to the situation of the cows and pressure of work, I was not able to weigh the ration of *shisham* foliage, but at a rough estimate it was about 8 lb. to 10 lb. per animal per day. In addition, the cows received 8 lb. of dry *juar* (*A. Sorghum*) or *bajra* (*P. typhoideum*) stalks of very poor quality. On the dry ration alone, I know from previous experience, the majority of the cows would have been after four weeks dead or dying of starvation. With the added ration of *shisham* foliage they markedly put on condition during the four weeks. In view of this fact, I append here the very interesting report by the Assistant to the Agricultural Chemist, Dr. Ramji Narayan, who, at the instance of the Director of Agriculture, kindly made an analysis of the foliage.

His statement that the zemindars of the province are averse to the use of *shisham* foliage is true generally of this district also. In comparison with *kikar* trees, *shishams* are not much lopped by local graziers ; however, the acute shortage this year did something to overcome this aversion, and *shishams* were being pretty extensively lopped here along canal banks before the rain came at the end of July.

Copy of analyst's report.

" I am submitting herewith the result of analysis of *shisham* leaves and seeds from the point of view of their use as a green fodder. Of the two samples analysed (i) was taken from near a water course and the (ii) from a place to which no irrigation water was ever given,

so that it corresponds with *barani* conditions. As there was practically no rain during last year, this sample corresponds with those obtained from regions of water scarcity.

Shisham leaves from—	Fat	Albuminoids	Soluble carbohydrates	Fibre	Ash	Albuminoid ratio	Food unit
Irrigated plot ..	3·30	7·92	57·48	18·77	12·53	8·17	72·76
Unirrigated plot ..	3·53	8·51	60·96	16·77	10·22	8·14	75·43

" A comparison of these figures shows that there is not much to choose between the two, although the second sample (*barani*) has a slight advantage in its fat, albuminoid and stable carbohydrate contents over the first. The real point, however, is to judge the value of *shisham* leaves as compared with other substances commonly used as green fodder. To form a correct idea of the food value of any feeding stuff it is absolutely necessary that the results of analysis must be correlated with digestibility coefficients obtained by direct digestibility experiments. In the absence of this the results are liable to be misleading. But, since it is not possible to carry on these experiments, the figures are given for what they are worth. For comparison, similar figures are given for other substances commonly used as green fodder, no such figure being given for grass, a term too vague and general, as it includes a variety of diffirent types of what collectively comes under the name.

Name of fodder	Fat	Albuminoids	Soluble carbohydrates (by difference)	Fibre	Ash	Albuminoid ratio (1 :)	Food unit
Green oats ..	2·25	5·7	54·6	24·2	13·25	10·48	65·46
Hay	1·78	3·41	47·23	33·85	13·74	15·05	54·74
Barley	2·21	12·10	40·31	32·15	12·73	3·75	57·50
Juar	2·59	6·29	44·95	31·32	14·85	8·10	57·20
Maize	2·80	10·20	41·98	28·07	16·97	4·75	58·62
Wheat	2·31	10·78	43·58	29·22	14·01	45·33	59·65
Shisham from irrigated plot	3·30	7·92	57·48	18·77	12·53	8·17	72·76
Shisham from unirrigated plot	3·53	8·51	60·96	16·77	10·22	8·14	75·43

"From a perusal of the figures given in the above table it is evident that as far as the albuminoid contents are concerned, barley, maize and wheat are the best, followed by *juar* and *shisham* leaves; while oats and hay have a rather poor albuminoid content. As to the food units, *shisham* and oats easily top the list, wheat, maize and *juar* coming next and hay being the poorest. *Shisham* leaves thus possess the highest food units, while the albuminoid ratio is equal to that of *juar*. Considering only these facts, it is apparent that *shisham* leaves are superior to oats and hay, and even *juar*. However, as I have said above, we will not be justified in drawing any definite conclusion in the absence of actual digestibility experiments. From what is known as a matter of fact, the zemindars of the province are averse to the use of *shisham* leaves for feeding their cattle. Their common belief based upon observation is that the cows' and buffalos' milk dries up when they are fed with *shisham* leaves and the observation is worth testing. However, nothing is known as to its effect on bullocks, a knowledge equally important to the zemindar."

Dry fodders.

As a rule, the only fodders that can be purchased locally are *juar* and *bajra kadbi* (dried stalks) and gram *bhoosa*.

Juar and bajra kadbi vary enormously in feeding value with each sample, according to the amount of leaf and flowering or seed head carried, individual thickness of stalk, time at which harvested, etc. Speaking generally, they are of poor feeding value. They are almost always cut too late. *Bajra* is grown mainly for the grain as a rule and is sown too far apart, and the stalks are too thick, bear little leaf, and have had the grain-bearing heads removed. This applies also to some samples of *juar kadbi*.

Gram bhoosa is probably of a much more constant constitution. Locally many cattlemen have a prejudice against gram *bhoosa*. Without actual experiment it is impossible to be dogmatic as to the value of any fodder, but so far as my experience goes gram *bhoosa* has a better value as fodder than either wheat *bhoosa* or the average sample of *juar* or *bajra kadbi*. The *bhoosa* is apt, however, to be a

good deal mixed with dirt and dust, and contains a varying proportion of unpalatable woody stalks.

Hay cannot (as a rule) be bought locally ; in the English sense of the term hay is not made in India, except by the military grass farms, by this farm, and in negligible quantities by private enthusiasts. However, large quantities of dry grass are cut and baled for sale as hay, chiefly from the central part of the country. The grass is generally cut much too late, and has a very poor appearance and feel. Its value as a fodder, however, is better than its appearance would indicate, probably because, owing to climatic conditions, it saves on the stalk, and retains when dried up a greater proportion of nutriment than is the case with grasses in Europe, which dry much more slowly.

Samples of this so-called hay of course vary a great deal, mainly according to locality where cut, period at which cut, and extent of damage received after cutting. As regards locality, cattle here, as a rule, refuse to touch coarse grasses from parts of the Himalaya foothills and Bhabbar, and I doubt if grasses from these localities are worth cutting for cattle at all, unless they can be cut and saved in the rains. Grasses from Central India, especially from the Jhansi Division, are however readily eaten and undoubtedly have a high value as fodder.

I have had considerable experience of feeding hay of this type to cattle here in 1915-16 and again to a less extent in 1921. Cattle undoubtedly do better on equal weights of these dry grasses than on *bhoosa* or millet fodders, and they have an additional advantage in that they can be fed without serious loss off the ground without being chaffed and no feeding troughs are required. Contractors in the business, however, are out for big profits, freight adds considerably to the cost, and even when hay can be bought at the same price as local fodders local cattlemen do not like it. This prejudice is, however, I think, due purely to ignorance and conservatism, and could be overcome if contractors could be induced to supply with a reasonable margin of profit. From my experience of hay making here, I consider that, unless their labour difficulties are altogether different from mine, their prices are most exorbitant.

I think, considering the enormous areas growing these grasses available to draw on, adequate organization should make it possible to save and import grass at a reasonable price.

Wheat bhoosa and barley bhoosa. Barley *bhoosa* is locally supposed to be preferable for cattle, but only negligible quantities are ever available here.

Wheat *bhoosa* is imported in some quantities in famine times, and a little is grown in the district. It is probably on an average the poorest in feeding value of all the fodders in general use. It is usually however available at a time (May and June) when most fodder famines are being most severely felt. It is difficult to handle unbaled, and is subject to loss in handling and feeding.

If it could be imported baled at a reasonable price, demand for it in famine times would probably be keen. I do not think it will ever pay to import at anything like the rates paid by the Army Department during the war. One would imagine however that the purchase price of wheat *bhoosa* in the canal colonies in normal times must be low enough to admit of its being baled and stored against famine at a reasonable price.

Proportion of concentrated feed to fodder.

In the case of the better fodders, such as hay, or good quality *juar kadbi*, dry cows and non-working cattle will keep going on a fodder ration alone. But in the case of most of the fodders usually available, to keep cattle in condition, or young stock growing, a small proportion of concentrated feed is also necessary. The quantity varies with the feed used. One seer daily is generally enough. *Cows in milk and bullocks in work require more,* but two seers daily is generally enough. If *shisham* or *kikar* foliage is available, the concentrated ration can be reduced, or in the case of dry, non-working stock, omitted altogether. The minimum quantity of fodder necessary depends on the fodder and the size of the animal fed. The average-sized dry cow here can support existence for a considerable period on 10 lb. of dry fodder plus 1 lb. of concentrated feed daily.

PRICE OF CATTLE.

During my short experience in India I have always been struck by the low prices of cattle compared with the prices of grain and fodder.

Before the war one could buy a really good four years old bullock for Rs. 120 and a good ten seers milch cow at the same or a smaller price.

If the owners had had to purchase the grain and fodder to raise the above animals to the age of four years, it would have, at a low estimate, taking grain at 16 seers, and fodder at two maunds to the rupee, cost him Rs. 165 for essential feeds alone, leaving out such items as salt and *ghee* (clarified butter) and the value of the milk drunk by the animal prior to weaning.

The average price of grain and fodder for the last three years is more than double the above rates ; the price of cattle, although rising, has not risen in proportion.

In fact, unless the breeder has grazing available for his cattle for the greater part of the year, I think it is impossible to rear cattle at present prices at a profit.

Considering that in this district grazing is often absent altogether, and generally good for only a few months in the year, it is curious that the industry continues to flourish.

One explanation may be, as regards the bullock trade, that the breeder generally breaks his bullock in young, and gets some work out of him before sale. The local breeders and dealers are all good feeders, and even in a famine year it is rare to see an animal at a local fair in anything but good condition. Most of the bullocks brought in for sale are always in fat condition.

The main trade of the district is, however, in young stock, aged about 12 months or so ; in some years these animals may have received little or no stall feeding prior to sale, but in their case it is just as difficult to understand how the cows to breed them can be maintained, considering the low prices realized for the young stock.

Grazing areas in India seem doomed to rapidly decrease ; it seems probable that the price of cattle must continue to rise

rapidly unless there is a marked decrease in the price of agricultural produce generally.

Amount of rain necessary to influence grazing.

It is not uncommon to see in the public press, especially in times of scarcity, after light rainfall, a paragraph to the effect that "half an inch of rain has fallen at such and such place, and that grazing will ensue to relieve the fodder shortage." As regards this part of India at all events such a statement is arrant nonsense. Isolated falls of rain of less than 1 inch have no effect on grazing so far as cattle are concerned.

Cold weather rain here has no effect on grazing, the Bir grasses all require considerable heat as well as moisture for any useful growth. Prolonged drought undoubtedly retards growth of grasses when moisture is supplied. Recently, practically no rain occurred for 11 months ; on July 14th the drought broke. A heavy shower occurred over some 5,000 acres of the Bir, an average of $1\frac{1}{2}$ inches fell over the affected area. In a normal year such a fall would have caused the area to become green in two days, and would have produced grass long enough for cattle to graze in a week. On this occasion, by the 22nd, eight days after the rain, the whole upland portion of the area was still brown. No germination of grasses had occurred at all except in a few depressions. Further rainfall occurred on the 23rd July, and after this upland grasses started to grow in a normal way.

SCOPE AND LIMITATIONS OF AGRICULTURAL RESEARCH. *

BY

RAO SAHIB M. R. RAMASWAMI SIVAN, B.A.,

Government Lecturing Chemist, Agricultural College, Coimbatore.

I TAKE it that every one of you is as much disappointed as myself, that Rai Bahadur Ganga Ram, the President-elect of the Agricultural Section, has not been able to come here to-day. Looking over the list of gentlemen who presided at this section in previous years, I find that they were heads of Agricultural Departments in India. Rai Bahadur Ganga Ram, however, is a retired Government official and a clever engineer by profession. After his retirement, he obtained large areas of land from Government, which he cultivated by comparatively more improved methods, and he utilized his knowledge of engineering to agricultural purposes, by promoting lift irrigation by steam and electric power. In fine, for several years after his retirement, he has been a successful agricultural engineer and business farmer. He is known to be a public-spirited gentleman, having endowed scholarships and prizes at the Agricultural College in the Punjab and having given very large donations to the Benares Hindu University. He has been apparently a trusted Government servant, being a Companion of the Indian Empire and a Member of the Victorian Order apart from his Rai Bahadurship. Those of us, therefore, who came to the Congress with the expectation of profiting by the advice and suggestions of a business farmer

* Presidential address at the Agricultural Section of the Indian Science Congress, Madras, 1922.

are thoroughly disappointed, and you, gentlemen, have probably a further disappointment in store, in that the section is to be presided over by myself. I have neither the departmental experience of past Presidents, nor the practical experience of a business farmer. To add to this, I was called upon to undertake the duties of the President of this section only last evening. That accounts for my inability to deliver an address worthy of the Presidential chair, for instance, a review of the progress of agricultural education or progress of agricultural chemistry or any similar subject on which, with plenty of leisure and necessary books of reference, I could probably have prepared one. Under the circumstances, I crave your indulgence for a few minutes when I propose to say a few words on the scope and limitations of agricultural research.

Research of all kinds demands in the worker a sound knowledge, a quick perception and a wide imagination, but agricultural research, in addition to the above, is beset with peculiar difficulties. First of all, it has to be remembered that agriculture is but an art, namely, the art of producing crops, and it includes the rearing of domestic animals ; but the practice of this art is governed by the application of a number of sciences, even a greater number of sciences than there are sections in this Congress. An intimate knowledge, fairly of a high standard, is demanded of a research worker, of all these sciences. Such wide acquirement of knowledge being impossible in these days of rapid scientific progress, specialization has come in, and agricultural research requires, therefore, the co-ordination of the intellectual energies of a number of scientists. Now this explains why some provinces which have a full complement of scientific experts have gone ahead of other provinces not yet fully staffed.

The second important point in which agricultural research differs from other researches is that almost everyone knows something of the art in this land of hoary traditions, wherein agriculture has been the backbone of the country and the most universally followed pursuit. The researcher has more often to learn from the illiterate cultivators than teach them. Indian traditions of

cultivation cannot be lightly set aside by these multicoloured scientists in their eagerness to apply their sciences to the art.

Thirdly, the conditions for the carrying on of agricultural experiments are mostly outside the control of the scientific worker. Soils vary from place to place in their physical and chemical characters, one season is not like another in rainfall, temperature and other climatic conditions, experiments have necessarily to be repeated several times, in several places and in successive years, before trustworthy results can be obtained, and let it be remembered that there is always the chance of negative results being obtained in any experiment. Even when what appear on the surface to be reliable results are obtained from experiments in the field, there is the question of probable error to be solved.

When we realize that a world-wide war was necessary to stimulate scientific research in general, and agricultural research in particular, in Great Britain, it is no wonder that there is a lack of faith in science and scientific methods in this country, and that there is a clamour for expeditious results from the public, including the members of the Legislative Councils. It is only when reliable results have been obtained that the scientific expert offers these results, through the agency of the district agricultural staff, for adoption by the actual cultivators, and I need not lay stress on the difficulties experienced by these district agricultural officers in their attempts to disseminate these ideas in the villages. In a word, their duties have all the charm and disappointments of a missionary worker.

While the majority of the members of the Legislative Councils have been conciliatory, even magnanimous, in their budget discussions when dealing with the development of the Agricultural Department, a few cries are heard, here and there, that the Agricultural Departments are white elephants. We often hear of criticisms that the researches of a scientific worker are more often of an academic nature than of any economic importance. Most researches are, probably in the beginning, only of an academic kind, especially to the on-looker, but they train the intelligent mind of the worker for deeper insight into the hidden problems of nature.

I am only voicing the opinion of the greatest scientists of the day when I say that harassing the researcher to produce quick results and economic results ends either in damping the spirit of the worker or in his producing haphazard work. So long as the experimenter is imbued with the true spirit of research, namely, the spirit of discovering and evolving truths of nature, and so long as he is qualified, by his knowledge and training, to undertake research work, a research worker may be left in peace, for it is *in his nature and to his interest* to carry on his work as quickly as possible, if not for the benefit of humanity, at least for the winning of his own laurels in scientific circles.

Granting the above conditions of the scope of agricultural research, the question arises, " Are we going on right lines ?" I believe we are. We are following generally the methods adopted, with success, in countries where science has made rapid progress, and as they have succeeded in those countries, we have to take it that we will succeed in ours, so long as due consideration is given to local conditions. That brings us to the agency, and, to begin with, we are grateful to the experts who have worked in this country from abroad. Some of us, at any rate, have had a training from them, and we are therefore welcoming the Indianisation of the department in the higher services which has already come and which will come in greater measure in the near future. Let me beg of you, gentlemen, to remember that this Indianisation connotes increased responsibilities. Where formerly we were content to be certified to as efficient assistants, capable of carrying out orders, we have now, as responsible heads, to think, to design and to direct. I, for one, have always held the opinion that this land, which can boast of a highly cultured civilization dating from ancient times, and of literature and systems of philosophy in no way inferior to those of other countries, is in no way deplete of master minds who can think, design and direct. I appeal to you, and I exhort you, younger members of the Congress, to remember that, as patriotic sons of India, it is your duty to render a good account of yourselves and produce such work commensurate with the money spent on you and your researches from the pockets of the cultivators. We have

been paid for in cash by them, and let us remember that it is an obligation on our part to return in kind in the shape of useful scientific work.

I will put the above ideas once again in one or two statements which I commend to every one. We have plenty of facilities. Utilize them to the best advantage. If any one should think that he is not paid sufficient wages in proportion to his talents, he has the option of resigning. When, however, he has chosen to remain, he should put the question, to be answered by his own conscience, "Is this all I can do?" rather than be satisfied with "This will do."

Gentlemen, I have done; but, before I ask you to listen to the papers announced, I would like to say a few words regarding the paucity of papers submitted to this section. It is possible that Rai Bahadur Ganga Ram did not think of taking the trouble to write to agricultural officers in different parts of India to exert themselves in getting papers ready—a procedure which was adopted by Presidents in some of the previous years. Again it has to be remembered that practically all the research work done by departmental officers find their place in departmental publications, for instance, Memoirs and Bulletins of Pusa, Provincial Year-books and Bulletins, and Agricultural Journals. Again in each province there has been an Agricultural Conference of some kind or other at which agricultural officers generally take part; for instance, we had at Coimbatore, only last month, our Agricultural Conference, at which eight or nine good papers were read. And, lastly, some papers seem to have been sent to the Secretaries too late for being included in this year's programme, and I am glad to announce that I have the permission of the committee of the Science Congress to use my discretion in allowing such papers to be read, and I shall be glad to exercise that privilege.

Gentlemen, I am thankful to the committee of the Science Congress for electing me Officiating President of the Agricultural Section, and to you, gentlemen, for the patient hearing you have given to my hastily thought out ideas.

NORMAL FLUCTUATIONS IN BODY WEIGHT OF BOVINES.

BY

G. P. GOFFI,

Laboratory Assistant, Imperial Bacteriological Laboratory, Muktesar.

THE general practice, when carrying out feeding experiments, of weighing the animals used once weekly or after even longer intervals is of but little value. As a means of comparing the suitability of a given ration or selected feeding stuff for a specific purpose, the data obtained from such weighings is open to much criticism. It will be shown in the course of these notes that fluctuations occur daily in the body weight of animals, and that the only satisfactory method of using the body weights of animals in comparing rations and feeding stuffs is to weigh the animals daily and to work with the averages of as many single weighings as possible.

Georgeson of the Kansas Experimental Station found the following variations at two different periods in the body weights of 3 steers being fattened.[1]

Weekly variations from initial weights.

Steer No.	Initial weight in lb.	FIRST PERIOD				Steer No.	Initial weight in lb.	SECOND PERIOD			
		Weekly gain or loss from initial weight in lb.						Weekly gain or loss from initial weight in lb.			
		1st	2nd	3rd	4th			1st	2nd	3rd	4th
1	1,232	+37	+48	+46	+93	1	1,545	+20	+52	+53	+65
2	1,190	+15	+23	+36	+60	2	1,583	+20	+37	+60	+23
3	1,207	+38	+29	+37	+63	3	1,567	+26	+52	+59	+25

[1] Henry and Morrison. *Feeds and Feeding,* 1916.

Weekly variations from initial weights—concld.

Steer No.	Initial weight in lb.	First period: Weekly gain or loss from initial weight in lb.				Steer No.	Initial weight in lb.	Second period: Weekly gain or loss from initial weight in lb.			
		1st	2nd	3rd	4th			1st	2nd	3rd	4th
1	1,232	+37	+11	− 2	+47	1	1,545	+20	+32	+ 1	+12
2	1,190	+15	+ 8	+13	+24	2	1,583	+20	+17	+23	−37
3	1,207	+38	− 4	+ 8	+26	3	1,567	+26	+26	+ 7	−33

Henry and Morrison[1] state that the variations found in Georgeson's experiments are not extraordinary. Fattening steers show such surprising variations in weight from day to day and even from week to week that the difficulty of estimating the true weight of an animal has led the American Experimental Stations to adopt the practice of weighing animals on three successive days, taking the average as the true weight on the second day. The same authorities, while giving no experimental evidence, say that the fluctuations observed in the body weights of animals seem to be governed by the following factors:—

(1) Movement of the contents of the digestive tract.
(2) The character of the food consumed.
(3) The exercise allowed or confinement enforced.
(4) And probably the quantity of water consumed.

Working with mice, Robertson and Ray[2] found that animals when weighed at short intervals throughout the day, between 8 A.M. and 10 P.M., showed fluctuations of body weight which occurred at fairly definite times during the day, and that these fluctuations corresponded to the feeding habits of the animals. The favourite feeding time was the early evening, with the result that the body weight was always high at about 10 P.M. In the early morning the weight was found to be low, while it increased during

[1] *Feeds and Feeding*, 1916.
[2] *Jour. Bio. Chem.*, XXIV, p. 347.

the morning only to drop again in the afternoon. Working with this data, they fixed the middle of the afternoon as the correct time for weighing their experimental animals, because at this period of the day the amount of material contained within the digestive tract was of relatively small bulk.

No reference can be found to any similar experiments having been carried out on cattle, but the general results are likely to be the same for all classes of animals, so that it is possible that the best time for weighing cattle will be found to be the early morning.

Armsby[1] quotes the record of a steer which had been receiving a fixed ration of timothy hay for two months, giving the daily weights for a period covering sixteen days. The animal was kept under as uniform conditions as possible and was weighed daily 24 hours after watering.

Daily recorded weight of Armsby's steer, with fluctuation from initial weight.

Day	Recorded weight in kgm.	Daily variations from initial weight in kgm.	
		Gain	Loss
1	419·0	..	..
2	431·6	12·6	..
3	431·0	12·0	..
4	440·6	21·6	..
5	431·2	12·2	..
6	444·8	25·8	..
7	427·6	8·6	..
8	427·9	8·9	..
9	437·8	18·8	..
10	436·0	17·0	..
11	437·2	18·2	..
12	443·0	24·0	..
13	428·4	9·4	..
14	433·4	14·4	..
15	436·8	17·8	..
16	418·6	..	0·4

The initial weight of the animal recorded was 419·0 kgm. and the final weight 418·6 kgm.; so that during a period of sixteen days

[1] *The Nutrition of Farm Animals*, 1917.

the loss in body weight amounted to 0·4 kgm. If, however, the total weights of the first three and last three days are averaged and the figures obtained are taken to be the true weights on the second and fifteenth days, then the gain in body weight would have been 2·4 kgm. and not 17·8 kgm. as shown in the above table on the fifteenth day. Had the animal been weighed after the initial weighing on the seventh day and fourteenth day only, gains would have recorded of 8·6 kgm. and 14·4 kgm. respectively. If instead of the seventh and fourteenth days, the weights had been taken on the sixth and thirteenth, the gains over initial recorded weight are 25·8 kgm. and 9·4 kgm. respectively. Had the experiment been commenced on the second day (431·6 kgm.) shown in the above table and terminated on the sixteenth day (418·6 kgm.), then the loss during these fifteen days would have been 13·0 kgm. instead of a gain of 17·8 kgm. when the calculations are made on the difference between first day (419·0) and fifteenth day (436·8).

Armsby as the result of his extended experience recommends :

(1) That large numbers of animals be used.

(2) That the experiments should extend over considerable periods.

(3) That comparison be based on the averages of as many single weighings as possible.

Since 1916 a number of feeding experiments have been carried out at Muktesar, the object in view being to work out suitable rations with the feeding stuffs available in the local markets for plains buffaloes used in the preparation of different sera issued by this Laboratory. In the earliest experiments weekly weighings were made, and the usual fluctuations were observed in the weights of individual animals as previously recorded by other workers. It was decided later to carry out a further series of experiments, but in place of the former weekly weighings to weigh the animals daily. Such fluctuations in the body weights were observed during the first few days that this experiment was hastily abandoned on the assumption that weights were being carelessly recorded.

The literature quoted in the early part of these notes did not become available till a considerable time after the feeding experiments had been stopped, and from a perusal of the data given by the few authorities quoted it was obvious that the variations observed in our abandoned experiments were quite normal.

A further experiment was now commenced on the following lines :—

(1) Two batches of normal plains buffaloes were used, one for the control ration and the other for the improved ration.

(2) The total weights of each group were as nearly as possible equal.

(3) As far as possible the animals were all of the same age.

(4) The animals were entirely stall fed.

(5) Weighings were commenced at 6 A.M. daily.

(6) Animals were not fed or watered until after they had been weighed.

(7) Both individual and group records were maintained, *i.e.*, daily recorded weights and the average weights which were obtained by averaging the weights of each three successive days and also each ten days weights (1st–10th inclusive, 2nd–11th inclusive, etc.).

(8) Charts were kept for entering such details, as "feeds fairly," "feeds well," etc.

(9) Both groups received the control ration for the first six days, and from the seventh day the animals for testing the improved ration received their proper food.

(10) When an animal fell sick or died a corresponding animal from the opposite batch was removed.

To illustrate the fluctuations observed in the body weights of normal plains buffaloes when maintained under practically uniform conditions for a period covering 88 days, the accompanying charts are given.

To show the charts of all the animals used in this experiment would require too much space, so that the records of one control ration animal and one test ration animal only are given. A study

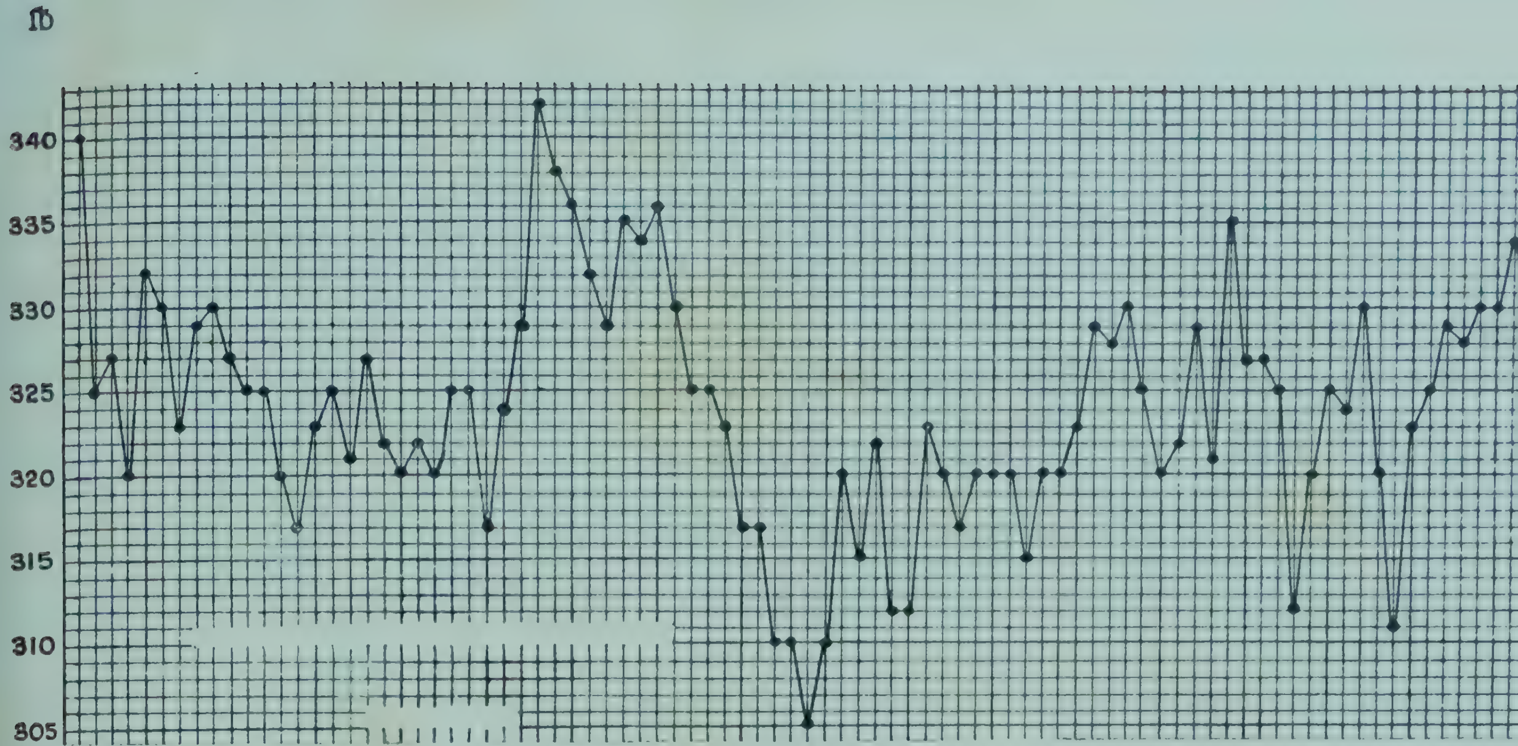

CHART I. Daily recorded weights; control animal.

CHART II. Daily recorded weights; test animal.

CHART III. Average of three successive weighings ; control animal.

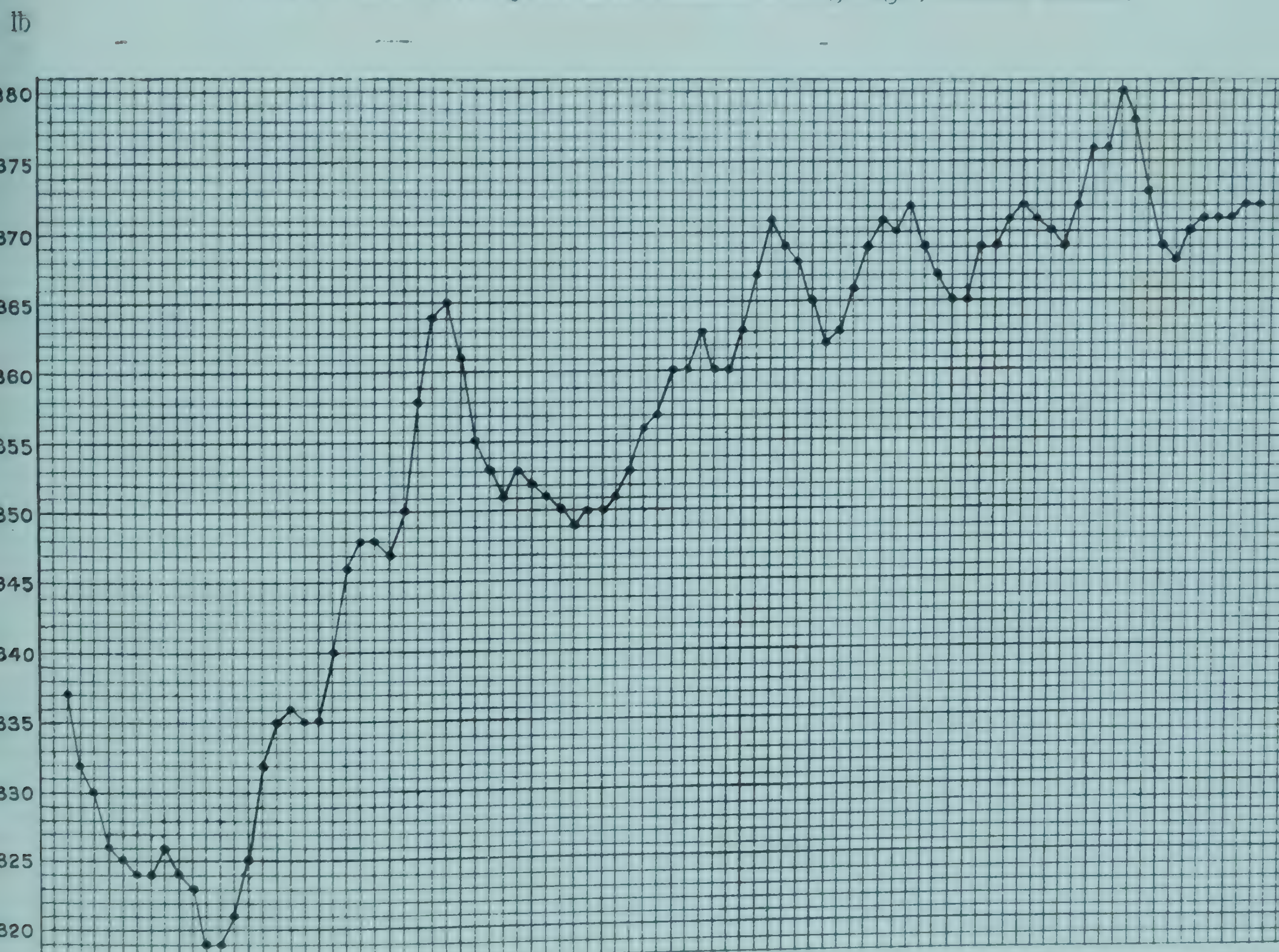

CHART IV. Average of three successive weighings ; test animal.

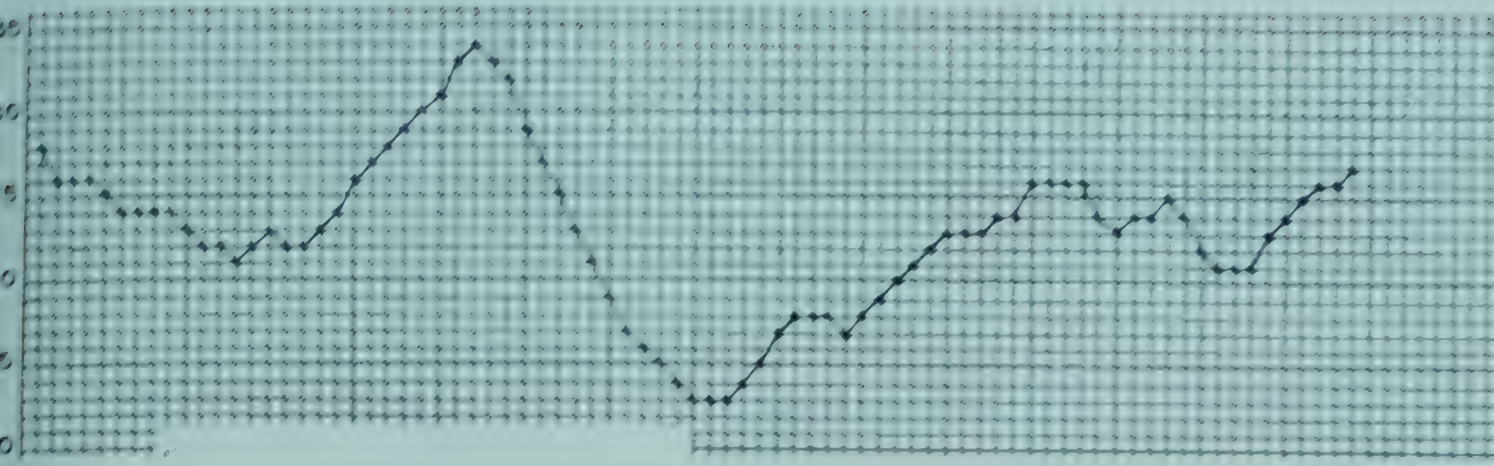

CHART V. Average of ten successive weighings; control animal.

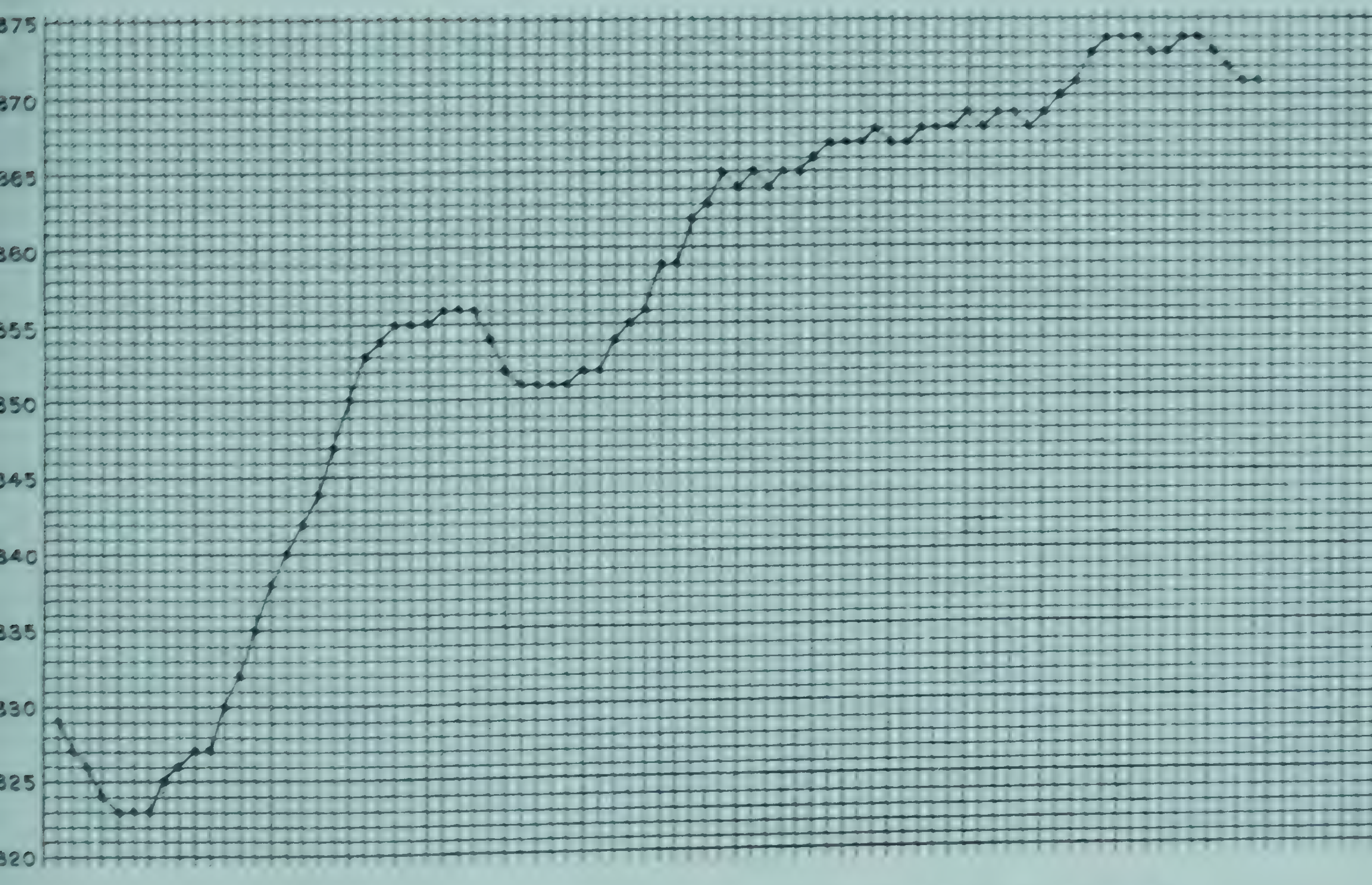

CHART VI. Average of ten successive weighings; test animal.

of these charts show the maximum fluctuations by the three methods used for recording results to be as follows :—

		lb.
(1) On daily recorded weights ..	(a) Control animal	13
	(b) Test animal	14
(2) On averages of 3 successive weighings ..	(a) Control animal	9
	(b) Test animal	8
(3) On averages of 10 weighings ..	(a) Control animal	3
	(b) Test animal	3

Results based on recorded initial and final weights.

Animal	Recorded weights		Gain or loss
	Initial 1st day	Final 88th day	
	lb.	lb.	lb.
Control ..	340	330	−10 (Chart I)
Test ..	340	370	+30 (Chart II)

Results based on the average weights of the first three and last three days.

Animal	Three days' average weights		Gain or loss
	Initial 1st, 2nd & 3rd days	Final 86th 87th & 88th days	
	lb.	lb.	lb.
Control ..	330	331	+ 1 (Chart III)
Test ..	337	372	+ 35 (Chart IV)

Results based on the averages of the first ten and last ten days.

Animal	Ten days' average weights		Gain or loss
	Initial 1st to 10th day	Final 69th to 88th day	
	lb.	lb.	lb.
Control ..	328	327	− 1 (Chart V)
Test ..	329	371	+ 42 (Chart VI)

From the above tables it is seen that during a period covering 88 days the control animal, when only the initial and final recorded

weights are considered, lost 10 lb. body weight, and the test animal over a like period gained 30 lb. When, however, the average weights of the first three days and last three days are used, the loss in one case is turned into a gain of 1 lb., and in the other the increase in weight rises from 30 to 35 lb.; while, had the average weight of the first ten days and the last ten days been used for making comparisons, the control animal was only 1 lb. under weight at the end of 88 days and the test animal had increased 42 lb.

A study of the weights recorded on every seventh day shows that both animals lost weight for the first three weeks of this experiment. The following table shows the recorded weights on every seventh day from the first to eighty-fourth day with the gain or loss on the initial weight and also the fluctuations from week to week.

Control animal				Test animal			
Day	Recorded weight	Gain or loss on initial weight	Gain or loss on previous weekly weight	Day	Recorded weight	Gain or loss on initial weight	Gain or loss on previous weekly weight
	lb.	lb.	lb.		lb.	lb.	lb.
1	340	..	..	1	340	..	..
7	323	−17	..	7	322	−18	..
14	317	−23	− 6	14	317	−23	− 5
21	322	−18	+ 5	21	339	− 1	+22
28	342	+ 2	+20	28	368	+28	+29
35	336	− 4	− 6	35	355	+15	−13
42	310	−30	−26	42	354	+14	− 1
49	312	−28	+ 2	49	357	+17	+ 3
56	320	−20	+ 8	56	360	+20	+ 3
63	330	−10	+10	63	377	+37	+17
70	327	−13	− 3	70	370	+30	− 7
77	330	−10	+ 3	77	383	+43	+13
84	330	−10	..	84	372	+32	−11

Had the weights of both animals been averaged for the first three weeks (1st, 7th and 14th day), and the last three weeks (70th,

77th and 84th days), and a comparison made, it would have been found that the control animal had gained 3 lb. and the test animal 49 lb. as against a loss of 1 lb. and a gain of 42 lb. when the averages of ten days' weighings are used.

Summary.

From the data given, it has been shown—

(1) That any conclusions as to the suitability of a ration or a feeding stuff for a specific purpose, when based on the data obtained from the initial and final weighings or on weekly or fortnightly weighings, are practically valueless.

(2) That the weights taken at intervals give no indication of the range of fluctuations that are occurring daily in the live weight.

(3) That weights should be taken daily and that it is advisable to average as many single weighings as possible. The most satisfactory results are obtained by averaging each 10 weighings (1st–10th day inclusive, 2nd–11th inclusive, etc.).

(4) That the use of averages reduces the error, but does not entirely eliminate it.

(5) That it is essential for the experiments to be carried on over long periods.

(6) That it is necessary that experiments be very carefully planned so that the conditions remain practically uniform throughout.

The object of recording these notes is to obtain the views and experiences of other workers in India on what is a matter of considerable importance. India for some years to come will have to depend entirely on the weighings of animals for controlling the results of feeding experiments, so that it is desirable that a standard method for conducting feeding experiments be introduced, thereby gaining results which will have the advantage of being based on uniformity of method.

PUSHT-I-KUH × HASHTNAGARI SHEEP AT THE AGRICULTURAL EXPERIMENT STATION, PESHAWAR.

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

In the year 1916, Sir Percy Cox, Resident in the Persian Gulf and Chief Political Officer, Basra, wrote to the Secretary, Foreign and Political Department, India, Simla, that officers concerned with the purchase of sheep on the Tigris had brought to his notice that exceedingly fine rams are occasionally brought in from the Pusht-i-Kuh for sale, weighing as much as 180 lb. live weight. They were reported to be broad-tail sheep superior to those of the type usually found in India, and to be well suited apparently for breeding with sheep in Baluchistan and the North-West Frontier Province. The Resident suggested that some rams might be imported into India to improve the frontier sheep. The breed was reported to be healthy, thrifty, sound in hoof, and accustomed to range over the hot stony hill-sides.

Some rams were imported, and four were allotted to the North-West Frontier Province. After a period of segregation they were brought to the Peshawar Agricultural Experiment Station in the spring of 1917. They withstood the fierce heat of the long summer days quite well. In September, when the breeding pens were being made up, two rams were sent to the comparatively cool valley of the Kurram, another was placed with a keen shepherd in the Hashtnagar tract of the Peshawar District, and the fourth was allotted ewes at the Agricultural Station. The progress of the Station flock only will be told now.

Fig. 1. Peshawari ewes.

Fig. 2. Imported Pusht i-Kuh ram.

In the North-West Frontier Province there are two distinct types or breeds of fat-tail sheep. One is called the Peshawari (Plate XIII, fig. 1). It has a short woolly fleece. The tail of a good ram is evenly spread out, flabby and pendulous ; it almost sweeps the ground. The tail of the ewe is far less heavy and droops still more loosely than the ram's. " Passages in the Old Testament prove this to have been the domestic breed of the ancient Israelites. Now the breed is widely distributed in Barbary, Syria, Arabia, Afghanistan, and various parts of Africa[1]." It is the popular breed in those villages in the Peshawar District where the fertile land is irrigated and intensively cultivated. Owing to the weight of the tail, the sheep cannot roam far in search of grazing, and the small flocks find suitable pasturage near home on the banks of the canals, by water-courses, in the clover fields and on stubble.

The second breed is called the Hashtnagari. Unlike the Peshawari type, sheep of this breed are able to range far for grazing. A typical specimen carries a comparatively heavy fleece of good "carpet-wool." The broad *compact* fat-tail is carried well above the hocks (Plate XIV).

The Pusht-i-Kuh is a far bigger sheep than either the Hashtnagari or the Peshawari. The ears are usually short and alert. The fleece is of an excellent "carpet-wool" quality. The tail, which is broad and very massive, falls well below the hocks. In general appearance, the Pusht-i-Kuh (Plate XIII, fig. 2) far more closely resembles the Hashtnagari than the Peshawari.

But the three breeds are akin, so it was decided to cross both the Peshawari and Hashtnagari with the Pusht-i-Kuh. A flock of 45 Hashtnagari and 10 Peshawari ewes was made up. The ram soon tupped the Hashtnagaris, but despite the fact that the breed to which he belongs has a very heavy and broad tail, he failed to mate with the fat-tail Peshawari ewes. Without some assistance from the shepherd, pure Peshawari sheep cannot breed : on the other hand, the Pusht-i-Kuh ram would brook no interference in his attempts to tup the Peshawari ewes ; he furiously butted the shepherd and

[1] *Standard Cyclo. of Modern Agriculture.*

knocked him down. It was suggested that the Pusht-i-Kuh might have tupped the Peshawari ewes if the more easily served Hashtnagari ewes had not been present. To decide this question Peshawari ewes were run alone with the Pusht-i-Kuh ram. Again he failed to tup them. Apparently the Peshawari fat-tail cannot breed with the Pusht-i-Kuh broad-tail. On the other hand, the broad-tail Hashtnagari ewes lambed in due season to the Pusht-i-Kuh ram.

The cross-bred lambs throve well on the same pastures and food as the local sheep. Despite their heavy fleece they bore the great summer heat with as little distress as the pure Hashtnagaris.

Throughout the Peshawar District and in most of the lower valleys of the North-West Frontier Province, it is far less profitable to breed for wool than mutton. The broad-tail Hashtnagari is a mutton and milk breed. For many years the Peshawar shepherds have bred Hashtnagaris to get early maturing lambs. For the reasons stated below they strive to sell their ram lambs in the city and cantonment markets when they are four to five months old.

(1) Pasture is scarce after the clover is off the land at the end of June.

(2) Neighbour cultivators will not let sheep roam over the land after the maize is sown in July.

(3) Young rams must be separated from the ewes when they are four to five months old.

(4) Few shepherds can afford to employ men to tend small flocks of rams.

(5) There is a good demand in the local markets for ram lambs.

For a period of three months after the lambs are marketed good ewes yield from 16 to 20 ounces of milk a day. Some shepherds convert the milk to *ghee*; others send it to the city and cantonment shopkeepers to be mixed with cow's milk.

Before considering the results of tests which were carried out at Tarnab, it is necessary to look at the parents of the cross-bred sheep.

At the age of four years the imported Pusht-i-Kuh ram weighed 170 lb. His fleece, which was of a superior "carpet-wool" quality,

Fig. 1. Hashtnagari ram.

Fig. 2. Old Hashtnagari ewe.

Fig. 1. Pusht-i-Kuh × Hashtnagari ram.

weighed 6 lb. In Plate XIII (fig. 2) he appears somewhat short in length of body and in life he actually was so. He has excellent constitution, but owing to the great weight of his tail he falls away too quickly at the rump.

The Hashtnagari ewe in Plate XIV (fig. 2) is a typical specimen of her breed. She is old, and as her lamb had been running with her for some weeks, she is somewhat poor in condition.

As the Hashtnagari ram (Plate XIV fig. 1) is only 15½ months of age he is not fully developed. He weighs 108 lb. He has a good length of body and carries his tail well. Of his breed he is but an average-good specimen. The following are some of the results of the tests which were carried out at the station :—

Weight for age.

	Age months	Live weight lb.
1. Pure Hashtnagari ram lamb ..	5½	69
2. The same	15½	108
1. Pusht-i-Kuh × Hashtnagari ram lamb	3½	61
2. The same	14	145

The rams were brought up together. They received all their mother's milk, but no grain ration. They had liberal and varied grazing on the banks of the Bara river, on stubble, and, on most afternoons from March till June, on clover. They were liberally treated but not hand-fed.

The Pusht-i-Kuh × Hashtnagari ram has proved the better sheep in most respects. At the present time, when he is only two years and seven months old, and has just been with his ewes for four weeks, he weighs 196 lb., which is 26 lb. heavier than his pure Pusht-i-Kuh parent weighed at four years of age. He has greater length of body, better constitution and loins, and carries his tail higher than the imported Pusht-i-Kuh.

The Hashtnagari ram (Plate XIV, fig. 1) is common-place in appearance compared with the handsome, deep-fleeced cross-bred (Plate XV, fig. 1). This Hashtnagari is the ram lamb which was taken for a live and dead-weight test that was carried out at the Peshawar Cantonment abbotoir. The Pusht-i-Kuh × Hashtnagari which was slaughtered for comparison was not nearly the heaviest in the flock. He was chosen because he was not suitable for breeding, his hoofs being unsound. The rams were reared together, and received a grain ration for one month only before they were slaughtered.

Live and dead-weight test.

Breed	Age months	Live weight lb.	Dressed weight lb.	Per cent. dressed dead to live weight	Pelt lb.	Offal lb.	Per cent. offal to live weight
Pure Hashtnagari ..	18	108	48	44·4	8	13	19·08
Pusht-i-Kuh × Hashtnagari	15	129	65	50·38	9	12	18·46

The kidneys of both the carcases had little fat, but the butcher, who has dealt with the frontier breeds of sheep for many years, explained that fat-tail sheep rarely have much kidney fat, that the fat in this breed tends to be deposited in the tail. The dressed tail of the Hashtnagari weighed 3½ lb., and yielded 2 lb. 6 oz. lard : the tail of the cross-bred weighed 9 lb., and yielded 6 lb. 15 oz. lard. The mutton of the cross-bred was more tender and of a better quality than that of the Hashtnagari.

Tests in fattening sheep will be carried out at Tarnab when cross-bred lambs can be spared for these. Although the shepherds breed for mutton, they would appreciate any improvement in the fleece which was not accompanied by unthriftiness, loss of weight, or falling off in the quality of the mutton. The fleece of the four-shearling Pusht-i-Kuh ram at Tarnab weighed 6 lb. The average weight of a Hashtnagari ram's fleece is 2 lb. A two-shearling Pusht-i-Kuh × Hashtnagari ram's fleece averages 5½ lb. in weight.

The samples of wool were submitted to the New Egerton Woollen Mills Company, Dhariwal, in June 1920, and the following is a copy of the report which the manager kindly gave on the samples :—

"With reference to your No. 951 of 5-11th instant, and in continuation of ours of 19th, we have to say that the samples proved too small for an exhaustive test. The following are the results obtained :—

Pusht-i-Kuh × Hashtnagari.	Per cent.
Yellow unburry medium long	32·10
" " coarse "	59·26
Grey " " "	8·64
	100·00
Scouring loss	4·2

Pure Pusht-i-Kuh	
Yellow unburry medium long	29·70
" " coarse "	53·47
L. Grey " medium "	3·96
Grey " coarse "	12·87
	100·00
Scouring loss	18·5

Pure Hashtnagari.	
White unburry coarse short	100·00
Scouring loss	13·8

The Pusht-i-Kuh has markedly improved the Hashtnagari sheep at the Agricultural Station, but as the introduction of outside blood often produces greater vigour than either of the parents possesses, the improvement may in a large measure be due to crossing. To gain permanent improvement it will be necessary to breed on true lines and select the sheep with care for some years. The Agricultural Station can distribute about 20 improved rams in a season, and as each of these may be expected to beget 20 sound rams a year, it might be thought that the Pusht-i-Kuh strain would be introduced to all the Hashtnagari flocks in a very short time. But the shepherds send their ram lambs to market when they are four to five months old. Each keeps one or two rams only for his

own flock ; no one breeds stud rams for sale. The shepherd who takes a good ram from the Agricultural Station will probably raise only one or two breeding rams from him. Whilst it is satisfactory to know that in this way only the best specimen of the improved type will be kept for breeding, it is disappointing that the holders of extensive areas of land do not follow the example of those landlords in England who breed pedigree rams to improve the flocks of their tenants.

Of the breeds which are most valued in South Africa for thriftiness, early maturity and good quality of mutton, the long-wool Persian sheep holds a leading place. The Pusht-i-Kuh and the long-wool Persian (Plate XV, fig. 2) are one and the same breed of sheep (Plate XIII, fig. 2).

Summary of conclusions.

The broad-tail Pusht-i-Kuh sheep closely resembles the Hashtnagari of the Peshawar District.

The broad-tail Pusht-i-Kuh ram cannot breed with the fat-tail Peshawari ewe, but breeds freely with the broad-tail Hashtnagari ewe.

Marked improvement in the rate of maturity, in the live and the dead weight, in the quality and the weight of the fleece is gained by crossing the Hashtnagari breed of sheep with the Pusht-i-Kuh, but as the introduction of outside blood often produces greater vigour than either of the parent breeds possesses, the improvement may in some measure be due to crossing.

To fix the improvement which has been gained it will be necessary to breed and select the cross-bred sheep on true lines for some years.

Selected Articles

THE STUDY OF AGRICULTURAL ECONOMICS. *

BY

C. S. ORWIN, M.A.

It is now about five and twenty years since research and educational work in agriculture began to be developed seriously in this country. Since that date a very great deal of effort has been expended in investigating the forces by which plant and animal life are controlled, and in bringing natural science to bear in every way upon the problems of food production. Work along these lines has been productive of most valuable results to the farmer; but at the same time the fact has been overlooked that, when all is said, farming is a business, and if it is to succeed as such it must be carried on with a clear regard for the economic forces which control the industry. So, whilst desiring nothing but the fullest recognition of work in the fields of natural science applied to the investigation of farming problems, I must express without any qualification the view that the equal importance of the study of these economic forces has never been adequately recognized.

Educational and research work in agriculture which takes no account of the dominant importance of economics must always be ill-balanced and incomplete, for farming business requires for its proper control a consideration of human relationships, of markets, of transport, and of many other matters which should come within the purview of the economist, as well as, or even more than, a consideration of questions regarding the control of plant and animal growth

* Abridged from the presidential address delivered to Section M (Agriculture) of the British Association at Edinburgh on September 12, 1921. Reprinted from *Nature*, No. 2720.

with which the man of science, in the limited sense of the name, is concerned. No one could wish to deny the need for the close and continual study of the soil and the means by which it can be made to produce more abundantly; no one could deny the need for research work in problems of animal and plant life. But the main concern of the farmer is to know not so much that which he can *grow* and how best to grow it as that which he can *sell* and how to sell it at a profit. Given the necessary capital and labour, conditions may be contrived under which any soil may be made to produce any crop; but the wisdom or otherwise of embarking upon any particular form of production can be determined only by a study of economic forces. In Bedfordshire, for example, considerable areas of very moderate land are met with given up to a most intensive form of agriculture; but land equally suitable for a similar form of farming may be met with in many other parts of the country which is producing not a tenth part of the value in food products nor employing a tenth part of the capital and labour, whilst at the same time the systems under which it is farmed are fully justified by the results.

The reason of the dieffrence, as doubtless everyone realizes, is that the land in the former case is so situated that it has access, in the first place, to supplies of organic manures on an abundant scale and at a cheap price, and, in the second place, to markets crying out for its produce, whilst one or both of these facilities are denied to the other areas. In the Chilterns district of Oxfordshire farming a generation ago was mainly directed to the production of corn and meat, and nothing that has arisen out of the work of the investigators along lines of natural science would have called for any radical changes in agricultural policy on these soils. But economic forces, inexorable in their effect, have brought about a revolution, and arable land previously under corn and sheep is now laid down to grass or occupied with fodder crops for the maintenance of the dairy herds which have replaced sheep throughout the area. Again, in the hill districts of England and Wales, there occur combes and valleys admirably adapted by soil and climate to the production of potatoes, and the highlands of Devonshire and Somerset may be

cited in illustration. In these places, however, in the majority of cases, even though good markets may exist—Somerset, for example, imports potatoes—the lack of transport facilities makes it impossible for the farmers to produce anything which does not go to market on four legs.

Coming last to the question of human relationships, we find that it is possible to organize much more intensive forms of agriculture than any of our own, which would be an enormous advantage to a consuming nation like Britain ; examples of such are to be met with in varying degrees of intensity in many countries. The Chinese, one reads, have increased production per unit area to an almost incredible extent, and in a lesser degree a similar state of affairs exists in parts of France and in Belgium (so often held up to us in this country as a model of productive capacity which we should strive to emulate). But in all these places the results are achieved only by a prodigal use of labour. The nation gains, no doubt, in the volume of produce available for its consumption, but the individual producer, deprived under this system of the opportunity to apply his manual effort in conjunction with an adequate amount of capital and land, is sacrificed to the consumer's advantage, and is driven to spend himself, year in and year out, for a reward for his toil to which the British worker, with so many alternative openings in more profitable directions available for him under our industrial system, would never for one moment submit.

These few illustrations may serve to indicate the overriding importance of the economic factor in farming just as in any other business. It is a common experience in industry that many scientific and technical processes are possible which are not profitable and it is in the light of the profit that they leave that all of them must be judged.

Economic conditions are subject to continual change, and the variations may be both sudden and extreme. This makes it the more needful to be continually recording experience and to examine it for the facts that emerge from which to obtain guidance for future policy. Much information is required both for national and individual guidance. Of late years, for example, there has been

much advocacy of more intensive cultivation of the soil ; it is said that by closer settlement and more intensive methods the production from the land could be much increased. On the other hand, there are those who advocate a development of extensive farming as being the only means by which to attract capital to the land and to pay the highest wage to the worker. Both sides to this controversy can and do produce evidence in support of their views, and some figures derived from a survey made by my colleague, Mr. J. Pryse Howell, will serve to illustrate both. The total area surveyed was 9,390 acres, divided into fifty-two farms of various sizes, and the region was selected by reason of the uniformity of the general conditions. All available data for each holding were collected, and after grouping the farms according to acreage the figures were thrown together and averaged for each group, with the following result :—

Production per unit of land and per unit of labour from holdings of various sizes.

Group	Acres	No. of farms in each group	Average size of farms	Average arable land per cent.	Altitude	Average rent per acre		Average men per 100 acres	Sales per acre			Sales per man		
					Feet	*s.*	*d.*		£	*s.*	*d.*	£	*s.*	*d.*
I	0–50	5	39	17	341–369	32	10	7·1	11	19	11	168	19	0
II	50–100	10	78	22	319–384	33	0	6·4	9	19	2	156	2	0
III	100–150	14	138	21	370–453	27	2	4·2	7	19	1	189	0	0
IV	150–250	11	201	11·7	330–411	28	4	3·3	7	5	8	222	12	1
V	Over 250	12	356	18·0	286–435	26	5	2·6	8	4	4	316	19	0

It will be noted that the conditions under which the farming is carried on in the various groups show no material differences as between one group and another, except in the matter of area. There is a tendency for rent to fall as the size of the holdings increases, but it is not pronounced, and in one case (Group IV) the percentage of grass land to arable land is considerably higher than in the rest ; but, considering the variations which must be expected in the conditions prevailing over any area of fifteen square miles, it may be claimed that in respect of altitude, quality of land, and proportion of arable

to grass, the holdings in these five groups are fairly comparable. Taking the results as they stand, the fact emerges that employment and production vary inversely with the size of the holding, but that the production per man employed varies directly with the size of the holding. Thus, on one hand, the advocates of closer settlement and the intensive methods which must necessarily follow if men are to live by the cultivation of small areas of land would seem to be justified in that the results shown by the survey indicate the highest amount of employment and the greatest product-value in the smaller groups. On the other hand, the advocates of more extensive methods of farming can point to their justification in that it is clear that the efficiency of management is greatest in the larger groups if the standard of measurement be that of product-value per man employed.

However, it is clear that either party is drawing conclusions from incomplete data. The efficiency of any farming system can be judged only by an examination of the extent to which all the factors of production are utilized and balanced under it. Each of the assumptions made from the figures above ignores entirely the factor of capital. Land, labour, and capital are all required for production, and the *optimum* system of farm management is that which utilizes all three together so as to secure the maximum result from each. If information were available as to the capital utilized in each of the five groups in the survey it might be found that in the smaller groups labour was being wastefully employed, and that an equal number of men working on a larger area of land with more capital, in the form of machinery equipment, would produce an equal product-value per unit of land with a higher rate of output per man employed. Equally it might be found that in the larger groups the use of more labour, or a reduction in the area of land, might produce the same product-value per man with a higher rate of output per unit of land. Obviously there can be no absolute answer to the question of what constitutes the most economical unit of land for farm production. The quality of land in certain cases, and market, transport, and climatic conditions in many more, make it impossible to determine even within wide limits the size of the

holdings on which the principal factors of production can be employed with maximum effect. Within similar areas, however, and in limited districts, much work can and should be done by agricultural economists to collect evidence on this point for the information of all concerned with the administration of land.

Another matter of the utmost importance to the farmer and to the public alike, and one which is crying out for investigation on a large scale, is the distribution and marketing of farm produce. Attention has been directed many times to the discrepancy between the price realized by the producer and the price paid by the consumer for the same article. In connection with market-garden produce, for example, the Departmental Committee on the Settlement or Employment onthe Land of Discharged Sailors and Soldiers stated in their Report (Cd. 8182, 1916) that "the disparity between the retail prices paid for market-garden produce in the big towns and the small portion of those prices received by the growers is utterly indefensible. It demonstrates a degree of economic waste which would ruin any other industry." No evidence was published by the Committee as to the facts upon which this conclusion was based, but a recent inquiry made by the Ministry of Agriculture into the prices prevailing at various stages in the distribution of vegetables in London may be quoted in confirmation of it. Figures were collected to show the amount received by the producer, the wholesaler, and the retailers for various classes of everyday garden stuff, with results as shown below :—

Producer's, wholesaler's and retailers' prices for market-garden produce, January 1921.

	Cabbages, medium grade, per doz.		Cabbages, bottom grade, per doz.		Cauli-flowers, top grade, per doz.		Sprouts, top grade, per 28 lb.		Turnips, medium grade, per cwt.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Producer	0	3	0	2½	3	0	3	6	3	0
Wholesaler	1	0	0	9	5	0	....		5	6
Retailers—										
(*a*) Stalls and barrows ..	2	6	2	0	6	0	....		14	0
(*b*) Suburban shops ..	3	0	2	6	8	0	....		14	0
(*c*) Stores and high-class shops ..	4	0	3	0	10	0	14	0	18	8

One has only to glance at the prevailing methods of distribution to realize their wastefulness. The street in which I live contains ten houses, and each day four milk-carts, three bakers' carts, three grocers' carts, and two butchers' carts deliver food to them. Twelve men, horses, and carts, not to mention a host of errand-boys on foot and on cycles, to deliver food to ten families ?

At the present time labour problems afford a useful example of the need for further investigation of the economic problems of agriculture. The labourer is often blamed for results which are due to the inefficiency of the farmer as a manager. When wages were low it may have been that the labourer was the cheapest machine, but in proportion as his remuneration approaches more nearly to the standard of reward in competing industries, so will the necessity for making his work more productive be intensified. The value of the output from the farm per man employed is not the only measure by which to gauge the efficiency of the management but is certainly one of primary importance. A man with a spade can dig an acre of land in about two weeks at a cost to-day of abou£t 4 10*s*.; a horseman and a pair of horses can plough an acre in about a day and a half at a cost of about £1 15*s*.; a farm mechanic on a tractor can break up an acre in about a quarter of a day, and although in the absence of sufficient data the comparison cannot yet be completed by reference to the cost of motor ploughing, it is fairly safe to suggest that when all the factors are considered—speed, less dependence upon atmospheric and soil conditions, as well as actual cost—there will be a still further advantage to be derived by investing the manual worker with the control of mechanical power. Thus it may be that high labour costs to-day are due in many cases less to the inefficiency of labour and more to the inefficiency of management.

In a recent issue of *The Times* an agricultural writer expressed the view that if the means existed for determining the proportion of the net returns of agriculture accruing to-day to labour, it would be found that labour was taking an excessive toll of farming results. This view is probably very generally held, and it affords a good example of the misconceptions which may and do arise in people's minds in the absence of exact information upon which to base their

assertions. This happens to be one of the questions which have been the subject of investigation at Oxford, though only on the small scale that the means at the disposal of the University have admitted. An investigation was made before the war of the distribution of the net returns of agriculture as between landlord, farmer, and labour. It was found that the proportions accruing to each of the three interests varied hardly at all, and that it would be safe to say that 20 per cent. of the total was going to the landlord, 40 per cent. to the farmer, and 40 per cent. to labour before 1914. Taking the above proportions, and calling each of these shares 100, the proportion of distribution between the three interests varied during the following six years as shown below :—

Distribution of the net returns from farming between landlord, farmer, and labour during the years 1913-14—1919-20.

Year	Landlord	Farmer	Labour
1913–14 (Standard)	100	100	100
1914–15	97	104	99
1915–16	94	108	98
1916–17	91	115	94
1917–18	90	111	99
1918–19	87	115	98
1919-20	89	109	102

The figures are interesting in several ways. In the first place they seem to disprove the suggestion referred to above, that labour has been taking an undue share of the net returns from farming, for an examination of the figures in the "labour" column shows that until the institution of the Agricultural Wages Board in 1917 the tendency was in the direction of a slight but steady reduction in the proportion coming to the workers ; the effect of the Wages Board Orders was to steady this tendency and, ultimately, to bring labour back approximately to the position it occupied in 1913-14. If the figures could have been continued for another year it is likely that they would show a material increase in the workers' share, but,

even so, it would be found that this increase had been achieved without reducing the farmer's share below his pre-war proportion. In the second place, the figures confirm the experience of landowners in that the landlord has received no part of the increased prosperity of farming, whilst, as everyone knows, his expenses of maintenance have enormously increased. Briefly, the situation is that, thanks to the Agricultural Wages Board (and its appointed members may take heart from the fact), the workers have been maintained in the same position as regards their share in the net returns as that in which they were before the war, whilst the farmer has received his share in the increase realized during the past few years, together with that which would have gone to the landlord had the pre-war scale of distribution been maintained. Rents and wages under normal conditions are slow to adjust themselves to changes in farming fortune, and, except in a time of violent economic upheaval, it is right that this should be so, for if the landlord may be regarded as a debenture holder, and labour as a preference share-holder, then the farmer, as the ordinary or deferred share-holder, has to bear the brunt, and if he must take the kicks so also is he entitled to the half-pence.

Turning now from problems in which either the nation generally or whole classes of the industry are concerned, it may be stated that there are many economic problems arising on the farm itself in the solution of which the individual farmer should be able to derive help from the economist. Some of these problems are so simple that their solution should be obvious, but the fact remains that waste in its most easily eliminated forms is constantly to be met with on the farm. The need for the study of the economic use of manual labour has already been referred to in another connection, but, granted that the balance between the employment of land, capital, and labour on any farm has been established, cases are continually met with where labour is being mismanaged. It is a not uncommon practice at threshing-time to take the horsemen from their work to assist at threshing, and as this operation can be performed only in dry weather, it may be assumed that the horses might usually be employed on threshing days. With manual labour costing about

7*s*. 6*d*. a day and horses about 5*s*. a day, the advantage of hiring casual labour for threshing, even at high rates of pay, will be obvious when it is remembered that the horseman whose horses are standing idle represents a daily cost for the manual work performed by him of some 18*s*. On a Midland counties farm, where the maximum possible horse-hours in a certain week in November last were 238, the time actually worked by horses was found to be eighty-seven, owing to threshing operations, and the wastefulness of the labour-management in such a case is obvious. Again, employers in certain cases object to paying Saturday overtime to men willing to work, because overtime payments are at a higher rate than those for ordinary time, but they overlook entirely the fact that the Agricultural Wages Board provides no overtime payments to the horses, and thus the cheapest horse-labour on the farm is that performed on Saturday afternoon at overtime rates of pay to the horsemen.

Everyone realizes, of course, the importance of keeping horses busy, but not everyone thinks how heavily the cost of manual labour is increased by idle horses. The maximum number of working days in a year is 312, a total obviously impossible of attainment in practice. Such records as are available show that the days actually worked by horses on the farm will not usually exceed four-fifths of the maximum. More time may be lost in summer than in winter, a fact not generally realized, and the period of maximum unemployment falls between haymaking and harvest. The busy seasons are, of course, the autumn and the spring, when the preparation of the ground for winter and spring corn is going actively forward. In the year 1918 figures were collected to show the percentage of days worked compared with "possible days" in each month on four farms distributed pretty evenly over England, and the results, thrown together, are as follows :—

Percentage of days worked to possible horse-days on four farms in 1918.

	Per cent.		Per cent.
January	67	July	38
February	82	August	65
March	77	September	78
April	74	October	80
May	70	November	67
June	56	December	64

Although the figures represent an average of four farms, it is noteworthy that the results on the individual holdings varied one from another in degree only, and that the months of maximum and minimum employment were the same in every case. The loss of time is far more serious than many people realize. The maximum possible horse-days in the year are 312, and the cost per day of the horse on the above four farms on this basis was 2*s.* 7*d.*, whereas, owing to the time lost, the cost on the basis of days worked was 3*s.* 7*d.* Whilst some difference is inevitable, so great a discrepancy as these figures reveal can be avoided by skilful management, and one of the tests of the farmer's efficiency is provided by an examination of the distribution of horse-labour throughout the year on his farm. His cropping and other work should be so contrived as to provide for the uniform utilization of horse-labour month by month. Under skilful management the differences in the number of days worked by horses from year to year are extraordinarily slight. On an East Midlands farm, employing twenty-three horses, the days worked per horse during the past six years have been as follows :—

Year	1913-14	1914-15	1915-16	1916-17	1917-18	1918-19
Days worked per horse ..	250·25	247	243	236	243	244·5

It may be noted, in passing, that figures such as those given for the seasonal employment of horse-labour emphasize the need for a study of the place of the agricultural tractor in farm management, for the busiest times of the year synchronise, more or less, with the seasons when the weather is more uncertain and suggest that the application of speedier mechanical power to field operations, in substitution for slower horse-power, would result in economic advantages in certain cases.

In connection with the study of economics on the farm the question of agricultural costings naturally suggests itself. Farmers, as a class, are not accountants and much less are they cost accountants, but this has not deterred many of them from taking part in discussions of farming costs which have been going on in the Press and in the Food Controller's offices for some time past, and the confusion of thought on the question of what cost of production

really is which these discussions have revealed is evidence of the need for study and education in costing processes. Few things can be of greater service to the farmer than scientific book-keeping carried out and interpreted with proper understanding, but few things can deceive him more than costing wrongly conducted or misinterpreted.

Lastly, I want to urge, and particularly before a gathering such as this, the importance of agricultural economics in agricultural education. The fact is realized, no doubt, by many teachers, but until a sufficient body of data bearing on the study of farm management can be made available to them, it is impossible for them to give to the teaching of practical agriculture that solid economic basis which is fundamental, and the teacher is driven to include in his instruction much to which the economic test has never been applied and to exclude more for which no basis for teaching exists at all. Given the requisite body of information, it would not only be possible but also necessary to recast the whole foundations upon which the teaching of practical agriculture rests.

THE WORLD'S COTTON CROPS IN 1921.*

YIELD NOT OVER SIXTY PER CENT. OF PRE-WAR TOTAL AND LITTLE PROBABILITY OF MARKED INCREASE THIS YEAR.

BY

PROF. J. A. TODD.

IN view of the fact that, whether it be due to a reduced acreage or to the lowest average yield on record, the American crop in 1921 is not likely to exceed 8,500,000 bales (including linters), which is the smallest crop recorded for 25 years, it becomes of special interest to enquire whether in any other part of the world there has been an increase of the supply to compensate for the loss in the American crop, or, on the other hand, whether the year's crops throughout the world have followed the same tendency as in America. In the latter case it is important to know whether the causes of reduction are similar to those which have operated in America.

UNRELIABLE INDIAN STATISTICS.

Next to the American crop, the Indian cotton crop is the largest in the world, though a very bad second both in point of quantity and quality. Before the war the area under cotton in India was about 25,000,000 acres, and the total yield had more than once exceeded 5,000,000 bales of 400 lb. American newspapers recently published an estimate of the world's crops for 1921, attributed to the Department of Agriculture, in which the Indian crop was given as 3,623,000 bales of 500 lb., compared with 2,845,000 in 1920

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* Reprinted from *Textile World*, 4th February 1922.

and 4,637,000 in 1919. As the two latter figures are obviously the equivalent in 500 lb. bales of the Indian Government's estimates for the two previous years, the figures given for 1921 would lead one to suppose that the Indian Government's estimate of the 1921 crop was 4,529,000 bales of 400 lb. (It was actually 4,330,000 bales as of December 1.)

As a matter of fact, however, the Indian Government's *final* estimate of the 1921 crop has not yet been published.* One of the difficulties of the statistical position in India is that the crop covers so wide a range of latitude, and therefore of climate, that the growing season varies enormously in different parts of the country. The first forecast, which appears in August, deals only with those parts of India whose season corresponds roughly with that of America, and as a rule accounts for about 60 per cent. of the total area. The second and third forecasts cover parts of the later sowing districts in the South ; but it is not until the final forecast, which is not issued until February, that it becomes possible to get any estimate of the *total* acreage planted throughout India, let alone of the crop expected therefrom.

Unlikely to exceed last season's total.

On the assumption, however, that the area still to be reported on this year will show a similar tendency to that of the earlier districts, it may be calculated at the present stage that the total area in India for 1921-22 will prove to be about 19,000,000 acres, as against the 1920 figure of 21,016,000. The 1921 monsoon was better than average, and at first it looked as if there would be a bumper crop ; but later reports have been much less optimistic, and it would therefore be rash to count on final crop figures in excess of those of last year, namely, 3,556,000 bales of 400 lb.

If the above calculation is correct, it will be seen that the reduction of acreage in India in 1921 was only about 10 per cent., which is less even than the revised figures for America. That,

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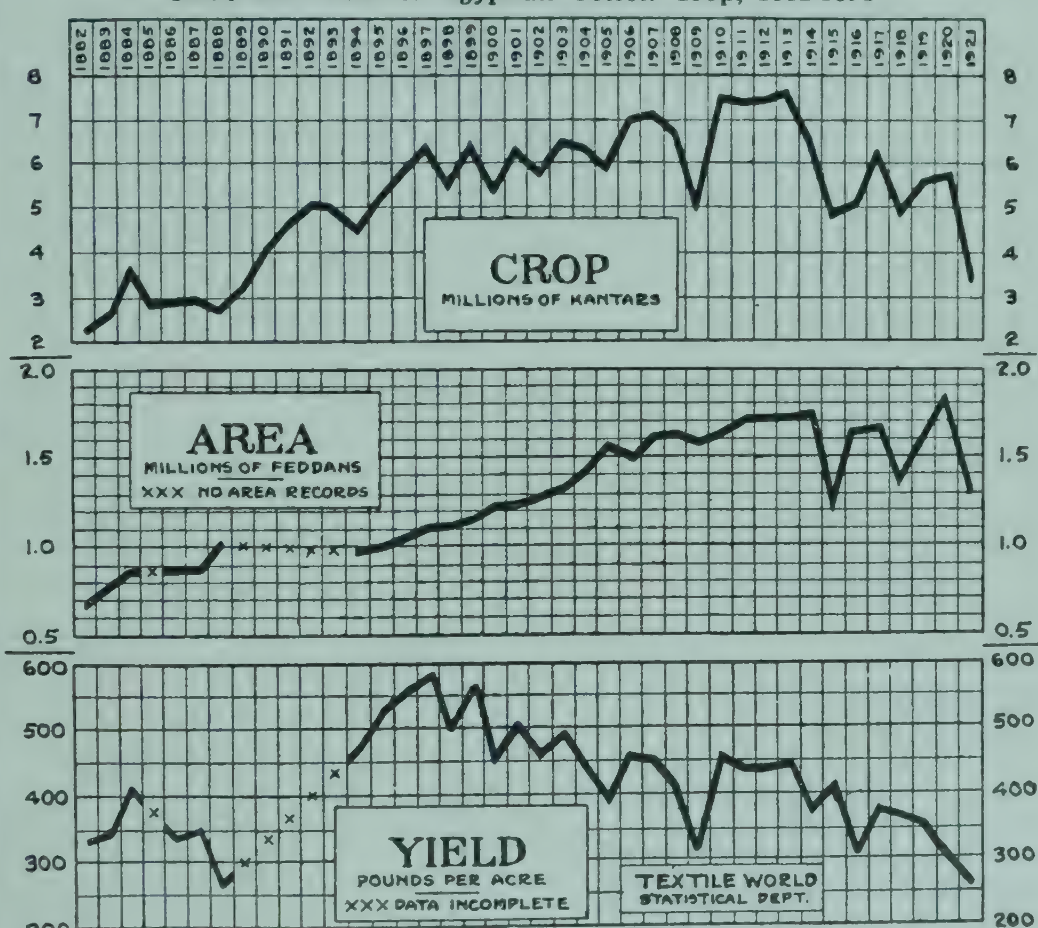
* The final estimate since issued shows 18,485,000 acres under cotton with a probable yield of 4,480,000 bales of 400 lb. each. [Editor, *A.J.I.*]

however, is to some extent natural, because as the sowing season in Southern India is in our autumn, prices in 1921 had risen substantially in time to lead to a larger acreage being planted in these districts, than would have been the case if the low level of prices in February had been maintained throughout the summer. And it is worth noting that these southern districts, *e.g.*, Madras, produce the largest proportion of what is called long staple cotton in India, though it only means cotton of about an inch in length.

India cannot make up for shortage.

This, however, emphasizes the fact that the bulk of the Indian crop is so short in staple that the actual amount of the crop really matters very little in the question of world statistics. That is specially true at the present juncture, because the American crop of

Area and Yield of Egyptian Cotton Crop, 1882-1891



(Crop and Yield for 1921 Estimated)

1921 contained, according to all reports, a larger percentage than usual of short and weak staple. Adding to this fact that much of the huge carry-over at the end of last season was also of poor staple, it is apparent that any addition that the Indian crop might make to the world's supplies will be, on the whole, of the kind that is least wanted. The immediate shortage to-day is of good cotton of $1\frac{1}{8}$ inch staple and over, and of that India produces none at all.

Egypt's reduced acreage and yield.

It is therefore to Egypt that the world turns with most anxiety to know whether the conditions there have been any more favourable than in America; but the facts are unfortunately quite the reverse. It would be hard to say whether the Egyptian crop or the American was the greater failure in 1921. On the first estimates there was little to choose between them as regards the acreage, for the legislation in Egypt restricting cotton to one-third of each holding resulted in a reduction of acreage of 30 per cent. as against the 28·4 per cent. reduction which was shown by the American Government's first estimate.

The area figures in Egypt are compiled by the officials of the Government Land Tax Department and judging by past experience there is no reason to believe that they are normally far from correct. It must be remembered that Egypt is a very small country from an agricultural point of view. Its total cultivable area is only about 5,500,000 acres as against the 700,000 square miles of the American Cotton Belt. Every holding, no matter how small, and over a million of them are less than an acre, is separately recorded in the Survey Books, so that it is possible to achieve a degree of accuracy in crop statistics which is unattainable in America.

The area in Egypt for 1921 then was 1,291,878 feddans, and upon this acreage, the Government estimate now indicates a crop of 3,300,000 kantars (a kantar is approximately 100 lb. and a feddan, an acre), which would indicate an average yield of 255 lb. per acre against the recorded maximum of 580 lb. in 1897. The worst of it is that, as will be seen from the annexed diagram, this is not a

new development, but merely the climax of a movement which has been going on more or less continuously for at least twenty years.

AN EXAMPLE OF HIGH YIELD.

Incidentally, it may be pointed out that there is nothing inherently improbable in the high figures of average yield quoted in the earlier years, because as a matter of fact such yields are easily equalled, either in individual cases in America, where the conditions are especially good, or in other countries like Brazil, where the normal conditions are superior to those in America. Again recent experience in Mesopotamia, where the conditions are more like those of Egypt than anywhere else, except perhaps Arizona, has shown conclusively that it is not difficult to get 500 lb. of lint per acre. In 1920 on an area of 80 acres near Bagdad, with native cultivators, most of whom had never grown cotton before, under conditions of political disturbance which could hardly be better than those of actual warfare, and which certainly resulted in irregular and inadequate irrigation, "Webber" cotton produced a yield of 1,250 lb. of seed cotton per acre, and it is probable that that figure will be exceeded in 1921.

CHIEF CAUSES OF EGYPT'S SMALL YIELD.

It is all the more disappointing, therefore, that Egypt, which we had always been accustomed to regard as the finest cotton growing country in the world, should have fallen on such evil days. The causes are unfortunately still to some extent a matter of controversy, but the chief of them may be enumerated as follows :—(1) Insect pests, especially pink bollworm; (2) lack of fertilizers, both natural and artificial; (3) excessive cultivation of cotton leading to alterations in crop rotations against the interest of good farming; and (4) the state of the soil as regards the balance between irrigation and drainage.

It is with regard to the degree of importance to be attached to this last cause, and the measures to be adopted to cure it, that the bulk of the controversy in Egypt since 1909 has arisen. It will

be seen from the diagram that the gradual fall of the average yield had begun even before the completion in 1902 of the Assuan Dam, but it was not until some years later that the fact of the reduced yield per acre, which had been disguised by the increased total crop due to extended area, was generally realized ; indeed, it was not until the disastrous crop failure of 1909 that the matter was brought home to the public and became the burning question of the day. The theory was briefly that the continuous extension of irrigation facilities, without a corresponding improvement of the means of drainage, had resulted in producing, in certain parts of the Delta, a water-logged condition of the soil.

The remedy was obviously twofold ; (*a*) to restrict the excessive flood irrigation, and (*b*) to improve the facilities for drainage. The first of these remedies was comparatively easily applied ; but the second involved very large engineering works, which only the weight of Lord Kitchener's influence was able to put through, against not only technical opposition, but also financial difficulties. The war and the consequent removal of Lord Kitchener's driving power resulted in the suspension of these schemes before they were completed ; and the huge pumping stations at the outfall of the main drains to the sea have never been taken in hand at all.

Future of project very uncertain.

In the meantime other controversies unfortunately arose, with regard to an entirely different, though related question, namely, the development of irrigation in the Sudan by the erection of a barrage on the Blue Nile, and the provision, by the erection of a storage reservoir on the White Nile, also in the Sudan, of a further reserve of water supply for Egypt. The result has been that partly due to these controversies, and partly to financial difficulties and the impossibility of obtaining the necessary technical staff under the present political conditions in Egypt, very little has been done since 1914, and the condition of Egypt remains little better than it was before 1909. A new Advisory Committee has been appointed to go into the whole question, but nothing has yet been heard of their coming to any decision on the subject. In the meantime the

political unrest in Egypt makes it very uncertain whether, even if a scheme were agreed on, it could now be put through without delay.

Pink bollworm has firm hold.

On top of these very unsatisfactory conditions came the invasion by the pink bollworm, and this certainly contributed substantially to the further decrease of average yield, which seems to have been checked for a time after 1909. The pink bollworm first became serious in Egypt about 1913, and the prompt measures which might have been taken to check its advance at the beginning were, unfortunately, prevented by the outbreak of war. The result is that the pest has now taken a very firm hold on Egypt, and complete extermination is not to be expected. Even to keep it in check will require continuous and painstaking effort, any relaxation of which is likely to lead to a prompt increase of the damage. It seems probable that the half-hearted way in which the cultivators went about the whole business of the crop this year, owing to the low prices, contributed substantially to the damage this year.

No marked increase likely in Egypt.

There is very little reason to hope for improvement in Egypt in the immediate future. It has been definitely announced that the restriction of acreage will be continued for at least two more years ; though those who have experience of the country may express some doubt as to the effectiveness of the restriction, when prices show so marked an improvement as they do to-day compared with a year ago. Certainly the crop this year will not suffer from the lack of interest on the part of the growers which seems to have accounted for a good deal last year. It is, of course, impossible to estimate in advance the probable amount of damage that will be done by pink bollworm, because its fluctuations depend not only on natural causes, but also on the efficiency of the measures adopted against it. Finally the crop yield depends on climatic conditions during the year, and especially on the character of the flood. It is impossible,

therefore, to say what the crop may be like this year; but although there is reason to hope that it will not be quite so bad as last year, it would be foolish to look for any increase which would materially reduce the appalling gap between the 3,300,000 kantars of last year and the record crop of 7,684,172 in 1913; we shall be lucky if we get half of that.

Finally, there is the entirely unknown question of political conditions, which at present are threatening in the extreme. Indeed that is about the only hopeful factor in the situation. Just because the authorities are fully prepared for almost any eventuality, any serious outbreak of disorder in the country is so much the less likely. In any case, the fellah has a wonderful capacity for attending to business when his livelihood is concerned, and confining political diversions to those seasons of the year when his crops do not demand his attention. Very soon he will be in the thick of preparation for this year's crop, and it is to be hoped that before that period is passed, some settlement may have been arrived at which will remove the possibility of any serious disturbance.

No early hope in Sudan.

Great hopes have been entertained in recent years that the Sudan might contribute materially to fill up the gap created by the failure of the Egyptian crop; but that hope, unfortunately, is not likely to be fulfilled in the near future. It is more than probable that the Sudan may some day become a great cotton country. It contains many small areas suitable for cotton growing, and one very large district in the Gezira, lying between the Blue and White Niles, where probably three million acres could ultimately be brought under cultivation, of which one-third would be available for cotton in rotation. But, as always in the Nile Valley, the whole scheme depends on irrigation, which in this case means the Blue Nile Dam. The enormous rise of construction costs, during and after the war, for a time gravely endangered the completion of this scheme; and at the best it will be three years yet before it is completed. Even then, the main canal as at present designed will only be sufficient to irrigate about 300,000 feddans, of which

only one-third will be available for cotton; and it will take some time to collect and train the necessary population to handle even that limited area. It is clear, therefore, that we cannot look to the Sudan, for some years to come at least, to contribute even as much as 500,000 kantars to the shortage of the Egyptian crop.

OTHER AFRICAN DEVELOPMENT LATENT.

The same is, unfortunately, the verdict with regard to all the other pioneer cotton growing areas which have within the last twenty years been tried in so many different sections of Africa, North, East, West and South. The British Cotton Growing Association, as well as the corresponding organizations of Germany, France, Italy, Belgium and Portugal, had, before the war, spent a great deal of energy, and a good deal of money, in trying out different districts all over the great Continent. Many of these had proved beyond doubt their possibilities of success; but there were still numerous difficulties to be overcome, and conditions to be fulfilled, before that success could be translated into large quantities of cotton. Irrigation and transport facilities, improved communications of all kinds, the training of native labour, and perhaps, above all, the provision of adequate marketing facilities, are difficulties which cannot be got over in a day.

Most of the pioneer work had necessarily to be suspended during the war; but since then the British Cotton Growing Association has been able to report substantial progress, which it is hoped will now be continuous. The Empire Cotton Growing Corporation has been set up by the British Government, endowed with a potential income of £150,000 a year, to be contributed two-thirds by the trade and one-third by the government; but owing to initial difficulties, the Corporation has hardly yet been able to do more than explore the field of its work. There is no good, therefore, in attempting to disguise the fact that the combined result of all these efforts, so far, hardly exceeds 100,000 bales per annum; and it would only be raising false hopes to pretend that the day when Africa will contribute an additional million bales to the world's supplies is not uncertain and far away.

China is cotton's "dark horse."

Turning to other parts of the world, there are two important areas which before the war were beginning to contribute substantially to the world's supply, namely, China and Russia. The former is still the dark horse of the world's supply, for no information of any statistical value whatever is available with regard to the crop. At one time it was placed by a quasi-official source as high as 4,000,000 bales; but that was almost certainly an exaggeration, and the figure of about 2,000,000 which is now generally adopted is frankly guess work. In one week lately two estimates were published, both from official trade sources, which were as far apart as 1,868,000 and 3,082,000 bales. The bulk of the crop is of inferior staple, mostly about the length of the ordinary Indian ; and it mainly goes into domestic consumption for the wadding of garments, etc.

Russian crop an unknown quantity.

The Russian crop was a much more hopeful proposition, and before the war had substantially exceeded 1,000,000 bales per annum; but it was founded on a quicksand, because the whole area in Turkestan, lying on the southern borders of Asiatic Russia, and in Transcaucasia between the Black Sea and the Caspian, was largely dependent on other parts of Russia for its food supply, which was brought south over long distances by rail. With the collapse of all government in Russia, and the consequent severance of these detached areas from communication with the outside world, it became necessary for them to grow their own food supplies, and that means the virtual cessation of cotton growing. The result is that the amount of the crop now is quite unknown, but it probably does not amount to 250,000 bales. Nor will it be possible to restore it to anything like its pre-war figures as long as Russia is in its present disorganized condition.

Causes of Mexican crop restriction.

In the American Continent (North and South) outside of the United States, there are many areas which could and should grow

cotton, but from which hitherto the world has drawn a very small proportion of its total supply. There is no doubt that Mexico could grow a very much larger crop than it does, for it possesses almost every variety of climate and soil suitable for cotton growing, under either irrigation or rainfall conditions. But whatever increase of the supply might have come from Mexico during the war years has been completely nullified by the political unrest from which the country has suffered, and there is no evidence that the immediate future is likely to show different results. Mexico, also, seems to be peculiarly favoured by insect pests, as the United States knows to its cost, and altogether it would be idle to hope for any material assistance from that quarter in the near future.

Wonderful possibilities in Brazil.

In South America, however, one country alone, Brazil, could, if properly developed, increase its crop to such an extent as almost of itself to meet any deficiency in the world's supplies and of almost any class of cotton. The International Cotton Federation recently despatched a special mission to inquire into the whole position in Brazil, and their report will shortly be available. From what is known of their views, it is clear that Brazil possesses conditions of climate and varieties of soil which make it almost ideal for cotton growing ; and it is hard to understand how a country so enormous in area and so favourably placed has in the past failed to produce more than the 560,000 bales which is believed to be its record output. The statistics are of course none too reliable, especially as in the South (Sao Paulo, etc.) so much of the crop goes direct to the local mills. But the one thing abundantly clear is that Brazil cannot only grow large quantities of good American cotton, but has also districts in the North which are actually producing long staple cotton that, with ordinary care in ginning and handling, might equal Egyptian. In fact there is considerable ground for the speculation that Brazil itself is at least one of the original homes of the group of cottons to which both Egyptian and Sea Island belong.

But the most astonishing feature of the conditions in Brazil is the almost incredible yields per acre, which can quite easily be

secured even under present conditions, and these are certainly not ideal as regards the care taken of the crop in any essential respect, *e.g.*, seed selection and the maintenance of a pure seed supply. Yields of well over a bale an acre are clearly substantiated ; and if only the system of handling the crop could be revolutionized—"improved" seems to be too mild a word—there seems to be no reason why Brazil should not become the greatest cotton growing country in the world.

A POSSIBLE SOURCE OF LONG STAPLES.

For the present, it may be doubtful whether it would be profitable to undertake the reforms which would be necessary to secure the development of the southern areas ; but with the coming scarcity of Egyptian cotton it seems highly probable that the world will be forced to have resort to those specially favoured areas in the North of Brazil, where large quantities of excellent long staple cotton could be grown. The problem bristles with difficulties, of which an inadequate labour supply is one, but they are no worse than are being faced to-day in every other country including America itself. At any rate it seems that, for a given expenditure of money, energy and time (and the last will probably be the most important of the three), Brazil at present offers the best prospect for an immediate return, in the form of a substantial addition to the world's supply of good cotton.

The mention of Sea Island recalls the disastrous position with regard to the world's supplies of that grade of cotton. Since 1918 the main portion of the supply, the Florida and Georgia crop, has dwindled to vanishing point. The output of the very best grades of the real "Islands" cotton in the Charleston district has sunk to a few hundred bales ; and even the West Indian crop, which is now practically the sole remaining world's supply of cotton of Sea Island quality, has suffered very severely during the war, mainly owing to the competition of sugar. Yet so extraordinary has been the position created by the abnormal conditions since the armistice, that the existing stock has apparently been more than sufficient to meet the demand, and prices have fallen almost worse relatively

than those of other grades of cotton. The explanation apparently is that during the war the belligerent Governments had commandeered practically the whole of the supply for aeroplane and balloon cloth purposes, and, as a result of cancellation of contracts after the armistice, the trade was left with a stock in hand sufficient to cover normal requirements for, it was said, at least two years. But since then the consumption has been going on at a rate which, in America alone (there are no separate statistics of Sea Island consumption elsewhere) amounted for a time to as much as the whole year's crop in a month.

Small supply and high prices probable.

Looking to the future there is simply no possibility in sight of an increased supply of Sea Island. The West Indian crop never amounted to more than about 7,500 bales of 400 lb.; during the war it sank below 5,000 and in the future it may be even less, because the pink bollworm has apparently secured a good hold in the Islands. So the fact must be faced that the world's future supply of Sea Island cotton will be infinitesimally small, unless the price rises high enough to make it worth while to extend its cultivation in the West Indies, and also in other small areas, of which many are probably available throughout the Pacific.

At the same time, it is probable that part of the American crop could be restored if it were profitable to adopt the methods now known for dealing with the boll weevil by calcium arsenate poisoning. These methods, however, involve considerable expense, especially in the form of labour; and their adoption is entirely a matter of economics. If the price of the crop is sufficiently high, they will be undertaken; not otherwise. It is possible again that earlier maturing varieties of Sea Island may be produced, which would give a feasible crop even under boll weevil conditions; but attempts along these lines will have to encounter the whole weight of the traditional belief that early maturity and long staple are opposite factors.

With all that could be done in these directions, however, it is certain that the supply of Sea Island for some time to come will

be extremely small compared with pre-war figures, and it seems inevitable that prices should rise to such a level as will restrict the consumption to the limits of the small supply available. There should, therefore, be a good time coming for the few surviving growers of extra long staple cotton, and this should react in favour of the very highest grades of Egyptian cotton, both in Egypt and elsewhere.

A SIXTY PER CENT. WORLD CROP.

To sum up, it is clear that nowhere in the world has there been a satisfactory cotton crop in 1921. On the contrary, the world's crops for that year will almost certainly prove to have been less than 60 per cent. of the pre-war figures. And before the war there were some people who spoke of a coming world's shortage of cotton. What will things be like next season, if the 1922 crops are only a little better than those of 1921 ?

RESEARCH IN ANIMAL BREEDING.*

IV.

BY

R. C. PUNNETT, F.R.S.,

Professor of Genetics, University of Cambridge.

In the previous articles of this series, published in the September and November (1921) *issues of the Journal, Professor Punnett dealt with the coat colours in cattle and the crossing of polled with horned cattle as illustrations of simple Mendelian inheritance. In the January* (1922) *issue of the Journal a description was given of the experiments undertaken with poultry and rabbits which were designed to investigate the inheritance of weight and coat patterns.*

ONE of the most striking points of difference between the higher animals and plants is that in the former the sexes are separate, while the latter are most often hermaphrodite. Associated with the bisexual mode of reproduction are peculiar features of heredity which have formed the subject of active investigation in recent years. As the result of much work in different parts of the world, the tangle of sex and its dependent characters is gradually being unravelled. In the first place we recognize sex itself as being inherited on Mendelian lines. Speaking generally, one of the features of sex-heredity is that the two sexes are produced in equal numbers. Male and female give males and females in like proportion, and it will be remembered that recessive and impure dominant give recessives and impure dominants in like proportion. Hence the conception that one sex is recessive and the other an impure

* Reprinted from *The Journal of the Ministry of Agriculture,* XXVIII, No. 4, July 1921.

dominant. The pure dominant can never arise, for male cannot be fertilized by male, nor female by female. Then comes the question, which sex is to be regarded as recessive, and which the impure dominant—which is the sex that produces germ-cells all of the same sex, and which the one that produces equal numbers of two kinds of germ-cells differing in their sex-determining properties? Experience has shown that there is no general rule for all animals. In man the male produces two kinds of sperms, but in the case of poultry it is the hen that produces two kinds of eggs; on the other hand, women and cocks agree in that each produces only one kind of germ-cell in respect of sex-determination. In man the two kinds of sperm decide the sex of the child; in the fowl the two kinds of egg determine whether there shall hatch out a cockerel chick or a pullet.

Earlier experiments, conducted in Cambridge, had revealed the existence of a peculiar form of inheritance to which the name sex-linked heredity was given. The nature of this may be illustrated by a case of the sort which was investigated on the University Farm. In discussing the Hamburgh-Sebright cross used for the weight experiments we stated that the Hamburgh was a gold pencilled, and the Sebright a silver. These colours were deliberately chosen as there was some evidence that gold and silver formed an alternative pair, and that the case was one of sex-linked heredity. The experimental work showed that this was so. Silver behaves as a simple dominant to gold, but in the hen the transmission of the factor for silver is sex-linked. The silver hen, no matter how bred, is never pure for the silver factor; half of her eggs are "silver" and half are "gold." Moreover she transmits the silver factor to her male-producing eggs, and the gold to her female-producing ones. If we denote silver by S, and gold by s, and maleness and femaleness by M and F, respectively, then the constitution of the silver hen is $MFSs$. Such a hen forms two kinds of eggs only, *viz.*, those bearing maleness and silver (MS), and those bearing femaleness and gold (Fs); and they are formed in equal numbers. This is at once apparent when she is mated with a gold male, $MMss$. All of the sperms of such a cockerel are of the same kind in respect of these

factors, *viz.*, *Ms*. The male eggs of the silver hen (*MS*) when fertilized by the sperm of the gold cockerel (*Ms*) give birds of the constitution *MMSs*, *i.e.*, silver males. The female eggs of the silver hen (*Fs*) when similarly fertilized give birds of the constitution *MFss*, *i.e.*, gold females. We have bred a great number of birds from the mating of silver hen and gold cockerel, and have never met an exception to the rule that the cockerels all come silver, and the pullets all gold.

This peculiar sex-linked type of inheritance is found in several other characters in poultry. It was demonstrated in America to hold good for the character of barred plumage such as is found in Plymouth Rocks. Barring is dominant to self black, but the barred hen is never pure for the barred factor. She transmits barring to her sons and black to her daughters. When mated with a black cockerel she gives only barred cockerels and black pullets. This observation we have been able to confirm in the course of our experiments.

As has already been pointed out before[1] sex-linked inheritance may prove to be of economic importance for the poultry breeder. Golds and silvers can be distinguished in the downs of the newly hatched chicks. By mating hens belonging to the silver class with cockerels belonging to the gold class, it is possible to tell the sexes apart *with certainty* immediately they hatch, and this is also true when barred hens are mated with black cockerels. By making use of suitable crosses the breeder of poultry for egg production can be sure of rearing nothing but pullets through the earlier and more costly stages. If the method were more generally followed, the poultry population of these islands would consist of a far higher proportion of the more valuable hen, and a markedly higher total production of eggs for the same expenditure of food and labour.

During the course of our work we have kept a number of pure breeds, and we have also made many crosses between them. A point that has impressed us greatly is the superiority of the first-cross birds as compared with the pure breeds. Under the same

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[1] Punnett, R. C. The Early Elimination of Surplus Cockerels. *Jour. of the Bd. of Agric.*, February 1919, p. 1319.

conditions the hatching power has been distinctly better, the chicks have been stronger, and mortality among them has been markedly less than for the pure-breed birds. The results have often been so striking that we feel it would be to the interest of utility poultry breeders if more extended trials could be undertaken. Carefully devised experiments of this kind might also be expected to throw light upon some of the vexed problems associated with in-breeding and cross-breeding.

Our investigations into sex-linked heredity have served to confirm and extend the earlier work at Cambridge where the phenomenon was first discovered ; and we should state that even ampler confirmation has been provided by other workers, notably in the United States. It is a phenomenon of great importance to the breeder, for it undoubtedly plays a large part in the heredity of animals with bisexual reproduction. Moreover, the understanding of it may prove to be of high economic value. Professor Pearl in America has published an account of some experiments which suggest that high fecundity in poultry is transmitted on these lines. The highest grade of laying hen owes this quality to the possession of a definite laying factor. But she is never pure for this factor, and, as it is sex-linked in heredity, she transmits it only to her sons. The high-grade layers therefore must get this factor from their father, and the high prices paid to-day for the sons of hens with a high egg record is evidence that the enlightened breeder is already taking advantage of Pearl's experimental work. There is evidence too that some factor leading to increased milk yield in cattle is transmitted on the same lines. Here, however, sex-linked transmission is by the bull, not by the cow. For cattle, like men, are mammals, and it is probably the male in mammals that produces two kinds of sperm differing in their sex-determining properties, while the female produces only one kind of ovum. The bull may transmit something to his daughters that he does not transmit to his sons.

The Cambridge work has also included another series of experiments dealing with a character of which the transmission is closely wrapped up with that of sex. In certain breeds of poultry

PLATE XVI

Fig. A. Skins of two silver-pencilled Hamburgh cocks, bred from the same hen. 1 is the skin of a henny cock, and 2 the skin of a normal-plumaged cock.

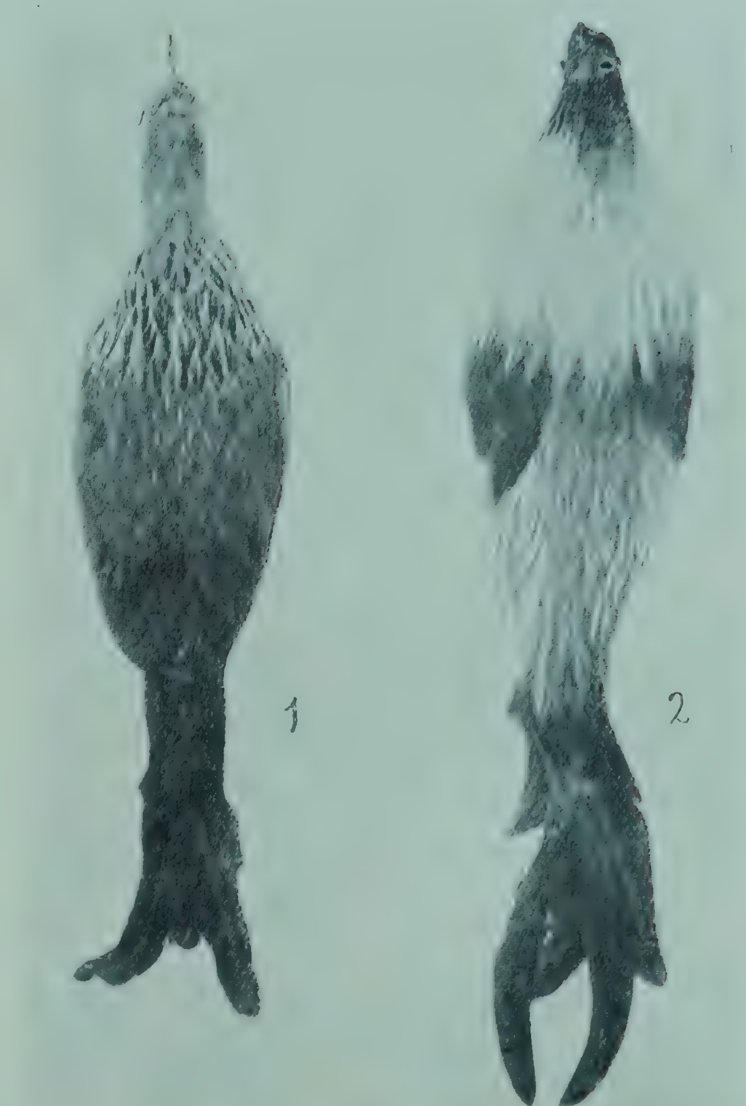

Fig. B. 1, skin of a henny cock. 2, skin of a castrated henny cock which moulted into norma plumage after the operation. Before the operation the bird was very similar to 1.

the cock is feathered like the hen. He lacks the long hackles of the neck and saddle, and the curved tail sickles of the normal male, their places being taken by feathers such as are normally found in hens. This feature of henny feathering in the cockerel is found in Sebright Bantams, Campines, Henry Game, and occasionally also in other breeds such as the Hamburghs (Plate XVI, fig. A1). In our experiments the character was introduced by means of the Sebright Bantam. We found that henny feathering was dependent upon a definite factor, and that henny feathering in the cock is dominant to normal feathering. In its first plumage the henny cock may be intermediate between henny and normal feathering, but when this is the case he takes on the henny plumage at his first moult. Either sex in henny breeds can transmit the henny factor. From a bird of a pure henny breed, whether cock or hen, crossed with a bird of a normal breed, all the cocks produced are henny. The hens, however, are like normal hens in appearance, nor is it possible to distinguish hens which transmit henny feathering to their sons from those that do not. The interesting point then arises as to how we are to regard normal breeds where the hens are hen-feathered and the cocks are cock-feathered. A marked step towards the solution of this problem was made by Pézard in France, and Goodale in America. Both these observers found that complete removal of the ovary, a very difficult operation, led to the castrated hen assuming cock-like plumage at the moult. The obvious inference is that the normal hen is potentially cock-plumaged, but that she forms a substance in the ovary which circulates in the blood, inhibiting the development of cock plumage, and rendering her henny. Further, since we can attribute henny feathering in the cock to a definite factor, we are led to suppose that the hen of normal breeds also carries this factor, though she transmits it only to her daughters, and they again only to their daughters. Interesting support of this view is derived from the results of castrating henny cocks. It is well known that castration of normal cocks has no marked effect, and that the plumage of the capon is similar to that of the uncastrated bird. Castration of the henny cock, however, results in the bird assuming the normal cock plumage at the moult. This was first demonstrated

by Morgan and Goodale in America, and has since been confirmed by Dr. F. H. A. Marshall in Cambridge. Plate XVI, fig. B shows the skins of a henny cock, and of a castrated henny cock which, after moulting, assumed the plumage of a normal Brown Leghorn. Before castration this bird closely resembled the henny cock shown in Plate XVI, fig. B1.

We must suppose that in the henny cock, as in the hen, the henny type of feathering is due to some substance circulating in the blood, inhibiting the production of normal male feathering. Moreover, this substance must be produced by the genital gland in the henny cock as in the hen. It may be produced by a testis as well as by an ovary. The hen is not hen-feathered in virtue of her femaleness, but because she has received from her mother a definite factor which she transmits only to her daughters in the sex-linked way. At some time or other in the history of the fowl this factor went, as it were, astray, and entered into a male-producing egg ; though how this came about we do not at present know. When, however, the dislocation happened it became possible to take advantage of it, and to build it up as a breed character. It is well known that the henny Sebright Bantams owe this peculiarity to a casual henny bantam cock that Sir John Sebright noticed about a century ago. Whatever may be the economic outcome, it is evident that the analysis of such cases as that of the henny cock is giving us a clearer insight into the problem of secondary sexual characters, which can never be neglected by the breeder.[1]

A few words may be said of some experiments undertaken in order to investigate the characters of egg-colour and broodiness in poultry[2]. That we were unable to work out these characters in the way that we desired is due to circumstances brought about by the War. When they were planned there was a fair prospect of funds being found for the extension of the work necessary to complete

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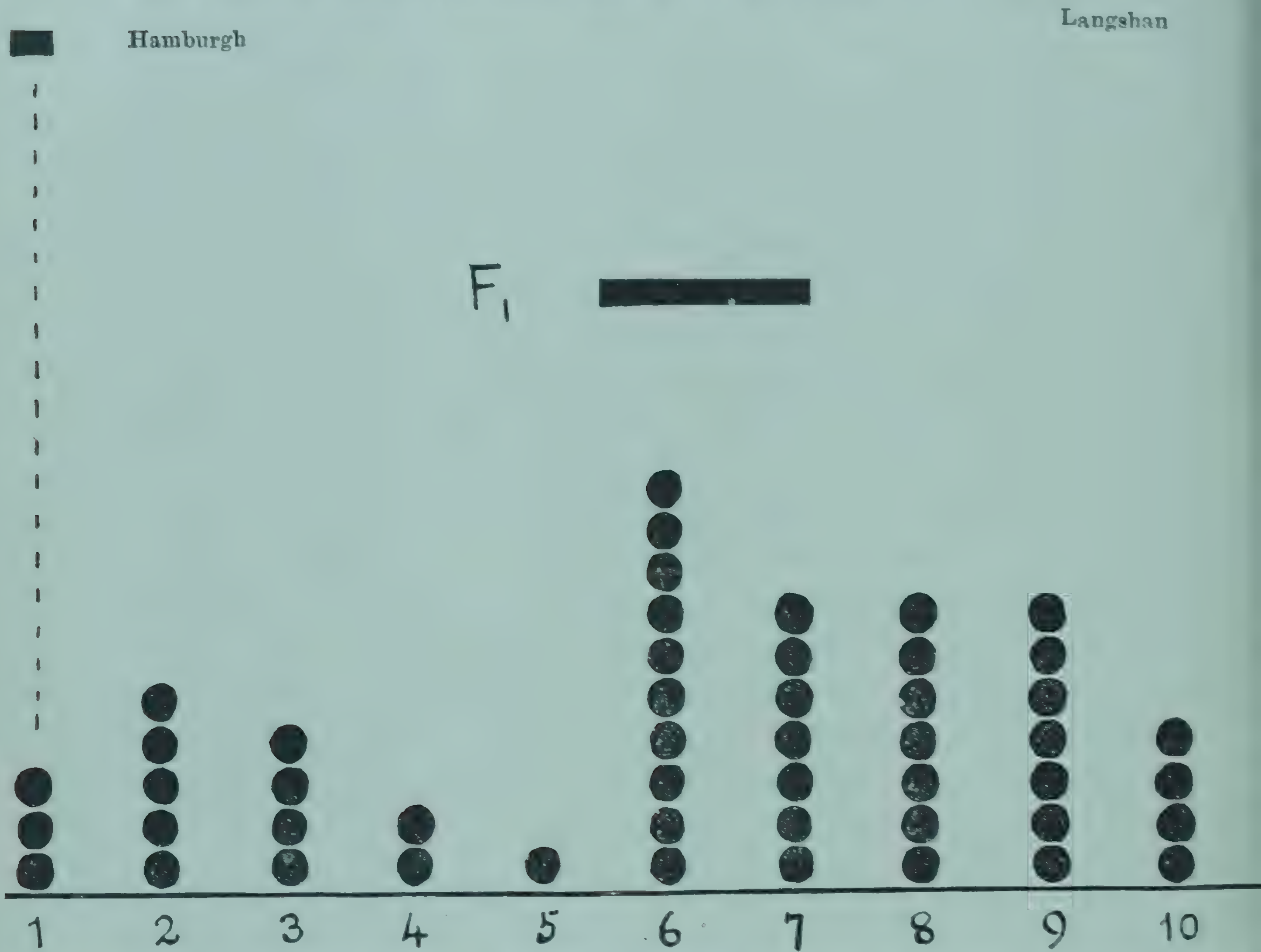
[1] A full account of this case will be found in the following paper : —Genetic Studies in Poultry. III—Hen-feathered cocks, by R. C. Punnett and the late P. G. Bailey. *Journal of Genetics*, XI, 1921.

[2] Genetic Studies in Poultry. II—Inheritance of Egg-colour and Broodiness, by R. C. Punnett and the late P. G. Bailey. *Journal of Genetics*, X, 1920.

it. War difficulties, however, forced us eventually to abandon the work before it was finished, and since the Armistice the funds available for this kind of research have not been sufficient to justify us in undertaking fresh experiments on these lines. Such results as we managed to obtain are not without interest, especially in view of the economic importance of the characters investigated. We began in the usual way, crossing birds of a brown-egg broody strain with birds of a white-egg non-broody strain. For the former we selected the Blank Langshan, and for the latter the Brown Leghorn and the Gold Pencilled Hamburgh. In respect of egg-colour the first-cross hens were intermediate, though the tinted eggs they laid approximated more to the lighter than the darker kind of the parental breeds. In the F_2 generation nearly 120 birds were tested and great variation was found. Some laid white eggs, a few laid dark eggs resembling those of the Langshan, while the great majority laid tinted eggs. The grades of tint varied from nearly white up to full brown. For a given hen the grade was fairly constant, though it varied somewhat with the season, especially in the case of those birds laying the more deeply tinted eggs.

In its broad outlines the case was not unlike the weight case in poultry; *viz.*, an intermediate F_1 generation of fair uniformity and an F_2 generation showing a full range of variation, between and including the two parental forms (Text-figure). It is probable that here also we are dealing with several factors, each of which influences the tint of the egg; and our experiments have shown further that such factors are transmitted by the cock as well as by the hen. There is evidence also of the existence of a factor which inhibits pigmentation of the shell, and this factor would appear to be linked with the factor for black down. F_1 birds from the Langshan and Brown Leghorn cross all have the dominant black down of the Langshan. In F_2 the brown-striped down of the Leghorn reappears in a quarter of the chicks. Our testing results showed that the layers of white and nearly white eggs were relatively much more numerous among the pullets that hatch black in down than among those that hatched brown. This peculiar linking of characters, though familiar to plant breeders, has not often been met with among

the higher animals. Probably this is because relatively little work has yet been done with birds and mammals. It is likely that, as our knowledge increases, these cases of linkage between characters will become more plentiful and it is not improbable that some of



The distribution of egg-colour among the pullets of an F_2 generation of Langshan × Hamburgh. The indicate the grades of tint from white (1) to brown (11).

them may turn out to have an economic value. For if a visible character, such as colour or pattern, were linked with such a character as higher milk yield, or more succulent mutton, breeding for these latter characters would be greatly facilitated.

Of our investigations into broodiness we can say little more than that they have shown the character to be a complex one. Hens vary greatly in this respect. Some go fully broody each year; others go broody occasionally and for a few days only; and all intermediate grades exist. Nevertheless our experience affords

grounds for supposing that the character can be analysed and expressed in terms of definite factors, though it is clear that the experimental work demanded would be both long and tedious. For in broodiness, as in egg-colour, the case is complicated by the circumstances that the factors are carried and transmitted by the cock, though he neither goes broody nor lays eggs. And the cock can only be analysed by mating him with hens of known constitution, and testing the nature of his female progeny which takes time.

Incidentally our experiments elicited a fact of some interest to poultry keepers. It is well known that the typically non-broody races lay white eggs, while the races that lay brown eggs belong to the broody section. It has been held that broodiness is necessarily correlated with the brown egg, and that it is not possible to establish a non-broody brown-egg race. Our experiments do not bear this out. It is true that the brown egg may be correlated with broodiness ; nevertheless, the linkage between the factors concerned, if it exists, is not complete, for we succeeded in combining the full brown egg with the non-broody character. We do not doubt therefore that, by working on the right lines, a non-broody race laying brown eggs could be established.

As a by-product of the above investigation we obtained data on the inheritance of leg-feathering. For the Langshan is a breed with feathered legs, while the Leghorns and the Hamburghs are clean shanked. Our own data, taken in conjunction with those collected by other observers, have served to show that at any rate two factors are concerned in connection with this character. As with weight and egg-colour, the factors produce a cumulative effect, and a continuous series is to be found ranging from excessive development in birds pure for both factors, to absence of leg-feathering where neither factor is present. For a detailed discussion, however, the reader may be referred to the original paper.[1] We have mentioned the case because it affords another

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[1] Genetic Studies in Poultry. I—Inheritance of Leg-feathering, by R. C. Punnett and the late P. G. Bailey. *Journal of Genetics*, VII, 1918.

example of what, at first sight, appears to be blended inheritance, though here again, as in the cases previously described, analysis has shown that the apparent blending is probably due to the cumulative effect of several definite factors.

Lastly, we may mention that in the course of our work we have gathered much information that is likely to prove of value for specific purposes. Our experiments with rabbits, for example, though designed primarily to study the inheritance of weight and certain patterns, have been used, as far as possible, to analyse the factors upon which the colour of the coat depends. In connection with the establishment of the natural rabbit fur industry, which is beginning to make progress, the information has already been of service to the utility breeder ; nor can it be doubted that, as our knowledge extends, it will prove of greater value in the future.

But after all the main object of the Cambridge work is the elucidation of the principles that underlie the phenomena of heredity. Once these have been revealed by research the application can be left to those who will derive profit from it. Of one thing, however, we feel sure, and that is that the breeder who masters the conceptions implied in the factorial theory of heredity will not only find in them a sure guide to practice, but will derive greater pleasure in the exercise of his craft as he sees fact after fact relating themselves to one another, and falling into place in a definite and orderly scheme.

Notes

EFFECT OF CASTOR CAKE MANURING ON *CHARI* (*ANDROPOGON SORGHUM* VAR. *VULGARE*).

Chari, like other fodder crops, is beginning to be very profitable to the cultivator in the neighbourhood of large towns where the growing demand for green fodder has greatly increased their price. The writer of these lines was trying to introduce an improved method of cultivation for imported varieties of sugarcane in his village Ajudhiapur about six miles from Lahore when it struck him to observe the effect of castor manure on the growth of *chari*.

For the cultivation of sugarcane the quantity of castor cake recommended to be used per acre is 46 maunds. But as *chari* ordinarily grows well without the help of concentrated manure it was thought fit to use only 20 maunds of cake. For the purpose of this experiment one *ghomaon* (5/6 of an acre) of land was set aside and 20 maunds of castor cake was used along with the usual quantity of farmyard manure. Another *ghomaon* was set aside for the cultivation of *chari* to which only farmyard manure was applied.

Chari was sown about the middle of June in the field to which only farmyard manure had been applied, and in the field in which castor cake had been used in addition to farmyard manure it was sown towards the end of the month. The quantity of seed used for the two fields was the same, 5 seers to a *kanal* (1/9 of an acre). The results obtained in the two cases were very surprising.

Chari grown in the field with castor cake attained its full height about the 20th of August, the average height of the field being 13·5 ft. It began to fructify very rapidly in the first week

of September. The average circumference of the stem was 2·4 inches, and the yield per *ghomaon* amounted to 665 maunds. Whereas in the other case the plants did not attain their full height till the middle of September and began to show signs of fructification only towards the end of the month. The average height of the plant in this case was only 6 ft. and the average circumference of the stem not more than 1·2 inches. The yield of the *ghomaon* in this case amounted to only 320 maunds. This was compared with the yield of other fields cultivated by the tenants, and it was found that 320 maunds was about the maximum for ordinary cultivation, the average yield for a good crop of *chari* being only about 275 maunds per *ghomaon*. [ANAND KUMAR.]

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A CASE OF PLANT SURGERY.

THERE is a gigantic Baobab tree (*Adansonia digitata*) at Bijapur probably more than 300 years old. Since the time of Alli Adilshah, offenders sentenced to death were executed on this tree (*Bijapur Gazetteer*). For this reason the tree is still known as the "Execution Tree."

The tree has a very thick stem with a girth of 49 ft. at 3 ft., 50 ft. at 6 ft. and 58 ft. at 10 ft. from the ground, where it divides into 3 huge branches. It covers an area of $\frac{1}{4}$ acre. Thus it presents a huge appearance and attracts the notice of every passer-by.

Being old, this tree was naturally attacked badly by rot and also the main trunk near the base, where there was a hole, and the whole of the heart of the tree had disappeared.

Being afraid of losing the tree, the District Judge applied to the Private Secretary to His Excellency the Governor of Bombay for its rejuvenation. I was deputed from the Agricultural Department for the work.

Encouraged by the successful results of similar work done on *Casuarina* and other trees in the Ganeshkhind Botanical Gardens, Kirkee, I proceeded to Bijapur and examined the tree. In the base, a conical-shaped hollow was found of the dimensions of 15 ft. × 9 ft. × 17 ft. The following operations were made during the 1st

week of September 1920. The hole was filled in with rubble and mud and concreted over. The affected parts were first cut out and it was found that the rot was due to the grubs of a large beetle. Hundreds of these grubs were cut out of the tree. As soon as the wound edges were cut down to sound wood, the wound was tarred over and then filled in with concrete. All the other parts which showed signs of attack or susceptibility to it within a short time were tarred over, and all places where water was likely to lodge filled in with concrete.

The District Judge was pleased to remark in his letter addressed to the writer as follows :—

"The result has been a most workman-like job, and the tree this year, though a famine year, at once reacted by producing a far finer foliage than was noticeable the year before. The whole job has been satisfactorily done and had attracted a large crowd who had never seen such a surgical operation on the tree before."

Within my knowledge this kind of operation has proved successful on the following trees in the Deccan :- (1) *Guruga pinnata* and (2) *Casuarina equisetifolia.*

I recommend this treatment with confidence to the attention of those who have an interest in saving their old mango and other trees. [L. B. KULKARNI.]

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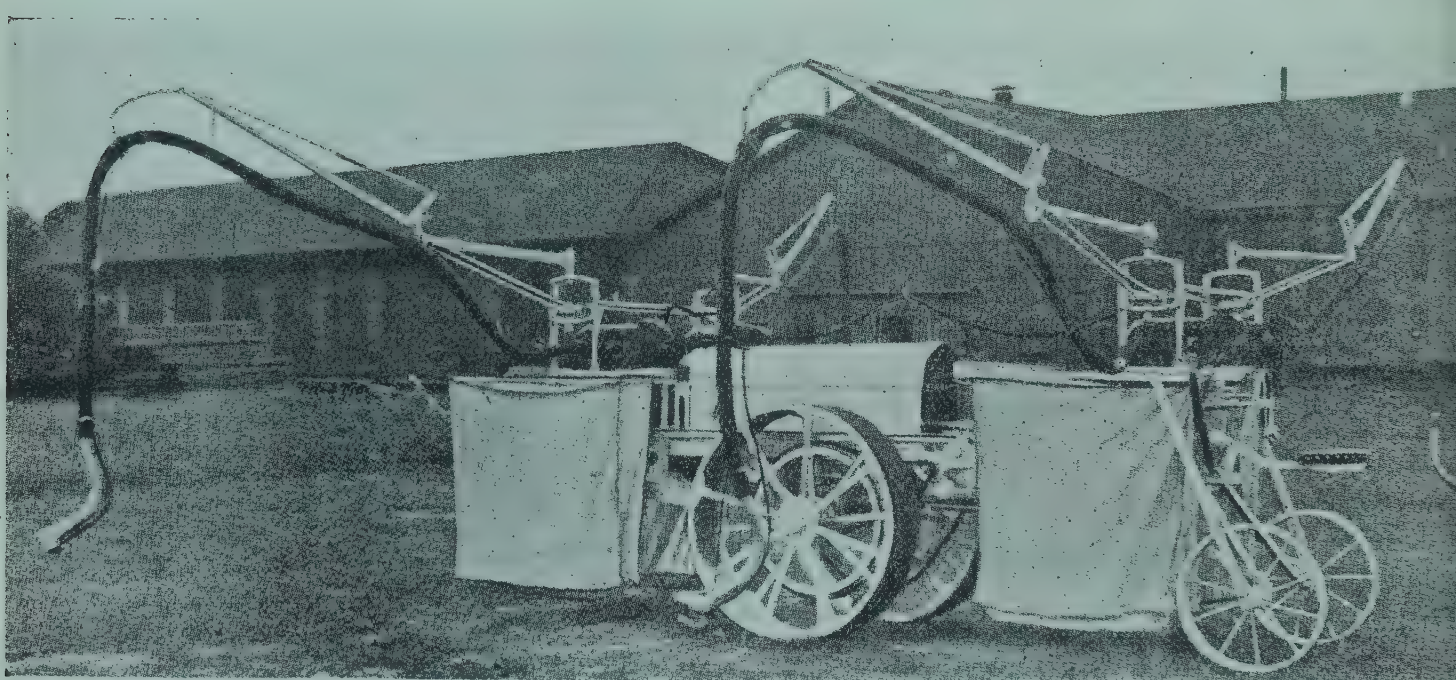
THE SUCCESSFUL COTTON PICKER.

THE cotton industry, in which human labour has played the important rôle for the 4,000 or more years that cotton has been picked by hand, promises to become revolutionized by the advent of an electrically operated picker, which has recently been perfected and placed in practical operation on a plantation at Little Rock, Arkansas, in the heart of the northern cotton belt.

This new electric device makes it possible for a person to gather from 400 to 700 pounds of cotton a day, as compared with 70 to 150 by hand. And by so doing it promises to solve the greatest problem of the cotton grower, that of being able to harvest all the cotton he

plants and to do so during the limited period in the fall before the rains and frosts damage the plants and greatly lessen the value of the crop.

It seems odd, yet is a fact, that any cotton grower can raise about three times as much cotton as his hired help can pick. Unlike the harvest of corn, wheat and other crops, where a machine cuts down the stalks and makes but one trip over the field for a harvest, there are three distinct crops to the cotton plant. This means a harvest period of two months or more and thus eliminates the floating labour element and makes each plantation owner entirely dependent upon his own help to pick cotton. Outsiders cannot be interested because of the slow and tedious nature of the work which brings such small returns and has always been the task of the negro.



Close-up view of the Stuckenborg cotton picker and the tractor that carries it.

This is but one feature of this twentieth century picker. Other points in its favour are not to be overlooked. Thus, it will result in cotton being picked when ripe, thus improving the grade two or three times and adding $ 10 or more to the value of a bale. By hand, but half the cotton of the South is being picked on time before it has deteriorated in value because of weather elements.

This latest attempt to replace hand picking may be called the life work of L. C. Stuckenborg, of Memphis, Tenn. He admits that he received his real inspiration leading up to the perfection of the present machine, when watching a cow which had broken down the gates and wandered into his cotton fields. Cows will eat cotton for the seeds embedded in the fibre; and as this cow went from plant to plant, he noted the ease with which the cotton was removed from the bolls by the animal's rough tongue.

After experiments extending over 14 years he perfected two revolving brushes encased in a metal frame about the size of a man's double fist. The brushes were made to revolve inwardly, thus creating a comb-like movement, and when these were placed against the cotton, pulled it free from the bolls without collecting any part of the boll or leaves of the plant. Then, having solved the plan for removing the cotton, he adopted the much tried suction idea for carrying the cotton to the receptacle to receive it. A flexible tube connecting with a bag on the machine did the trick.

Each machine carries a complete electric power plant. The tractor engine furnishes sufficient electric power to operate the eight motors required to run the machine. The brushes in the leads are driven by a flexible drive-shaft about three feet long, which is connected to a small motor suspended about half way down the suction tube. After the cotton completes its trip through the tube and just before it drops into the bag, it is given a cleaning by fanning, another motor operating the blower as well as providing suction power.

There are four picking tubes to a machine, each with its pair of motors. Supported overhead by a balance arrangement, the pickers are suspended with such lightness and flexibility that even a child could shift them about with ease. The machine as it passes through the field can pick eight rows. The negro—and several have been tried on the machine—finds no trouble in using it; and in checking up his work it has been found that where he formerly picked 100 pounds by hand he has, with only a few days' training, been picking 400 pounds by machine. [*Scientific American*, March 1922.]

PINK BOLLWORM IN THE UNITED STATES.

The authorities in charge of the pink bollworm control work in Texas and Louisiana plan to make a trial of the efficacy of a two-year non-cotton period as a means of exterminating the pest in Cameron Parish, Louisiana, in an isolated district where fields have been kept absolutely clean of cotton for two years. It is proposed to plant this district, or areas in it, with cotton in the coming season, in order to see whether or not pink bollworm will appear there. If this cotton is attacked by pink bollworm it will have to be concluded that a two-year non-cotton period is not enough, unless it can be shown that the insect has been able to make use of other plants than cotton for its maintenance.

The results of this trial will be of great interest and importance, since it will provide an answer to the question as to whether it is necessary to maintain a non-cotton period longer than two years in a campaign for extermination of the pink bollworm. In the United States, the cotton growers are compensated by Government if they are forbidden by law to grow cotton, provided it can be shown that no other crop of equal value can be substituted for cotton. It is very important, therefore, that definite information should be had as to the length of time for which it is necessary to prohibit cotton growing in order to achieve the required results.

In 1916, when cotton seed from Mexico was allowed to enter Texas for crushing at the oil mills, the oil mills at Dallas received some 15 car loads of this seed. The seed was promptly crushed and no infestation of cotton fields resulted. Now, however, the pink bollworm is reported to have been discovered in cotton fields in Ellis County, which is just to the south of Dallas County.

Ellis County is said to be the largest cotton-producing county in Texas, the cotton crop amounting to as much as 1,50,000 bales per year. Information is wanting as to the area actually infested, and as to the prospect of the pest being eradicated from this district.

The pink bollworm (*Pectinophora* [*Gelechia*] *gossypiella*) is now recorded as occurring in the Island of Porto Rico. It is

understood that the distribution of the insect in the island is general, but that the infestation is of fairly recent origin. [*Agricultural News*, XX, No. 512.]

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COTTON RESEARCH.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

Cotton cultivation in Colombia.

The production of cotton has been increasing rapidly in recent years. The cotton grown in Boyaca appears to be indigenous to the district. It is grown by the peasants in small patches often with admixture of other crops and, though little or no preparation is given to the soil, the cotton produced is generally of good quality. Two kinds of Boyaca seed-cotton have been examined. Both were of good quality but one had a dark colour and would meet with only a limited demand. The other had a good colour and would be readily saleable. [*Bull. Imp. Institute*, 1921, **19,** 18-20.]

Cotton cultivation in Cambodia.

Two types of long staple cotton, cultivated on the red lands of Cambodia, have been tested. In one case the cotton was clean, white, of woolly appearance and rather coarser and more brittle than American fibre. Its average staple length was 25-26 mm. The second cotton has an average staple length of 23-25 mm. and was slightly yellow in tint. The tests were carried out on an industrial scale and proved completely satisfactory. These cottons give yarns comparable with those obtained from American cotton but their use is limited to the production of coarser counts. It is recommended that, by selection and crossing, finer Cambodian cottons suitable for the production of fine counts should be cultivated. [*L'Ind. Text.*, 1922, **37,** 10.]

Physical characteristics of cotton plant.

Correlations are determined for — (*a*) number of base limbs with number of fruiting branches, number of bolls per plant, and height of plant ; (*b*) number of fruiting branches with height of plant and number of bolls per plant ; (*c*) length of fruiting period with other characters, including length of lint and percentage of lint, weight of boll, and weight of seed ; (*d*) weight of seed and weight of boll ; (*e*) percentage of lint and weight per boll. [*Exp. Sta. Record,* 1920, **43,** 530 ; from *Arkansas Sta. Bull.* 169 (1920), 3-15. E. A. Hodson.]

Resistance of cotton plant to alkali.

A series of soil analyses illustrating the resistance of certain crops, including cotton, to alkali under field conditions are reported. In general, 0·1 per cent. seems to be the limiting amount of black alkali for these crops. Later observations show good cotton produced on soil containing 0·4 per cent. soluble salts with a low chloride content, stunted and unprofitable cotton on soils containing 0·4 to 0·6 per cent. soluble salts with 0·1 to 0·3 per cent. chlorides, and total destruction of the crop on soils containing upward of 0·6 per cent. soluble salts of which one-half or more was chlorides. [*Exp. St. Record,* 1920, **43,** 724 ; 1921, **44,** 519—from *Arizona Sta. Rpt.*, 1918, 342-345 ; 1919, 408, 409. C. N. Catlin.]

Effect of cotton wax on strength.

The author reports that the experiments of the Cotton Research Co. have shown that the removal of wax increases the strength of cotton yarn by 15—20 per cent., the yarns being tested under the same conditions of humidity. This is probably due to increase of friction. On the other hand, removal of the wax is likely to reduce the wearing properties of the yarn. There is also a relation between the amount of wax and the percentage of short fibre in a sample of cotton. Consequently, many of the theories of the action of the wax may have to be revised by paying more attention to the short fibre. [*Text. World,* 1921, **60,** 3501. C. E. Mead.]

We are indebted to the Secretary, Indian Central Cotton Committee, for the following abstracts :—

Stress strain curves of various yarns, by G. F. New, B.Sc., Linen Industry Research Association. (*Jour. Text. Ind.*, XIII, 2, Trans.)

A description of a method for determining the stress strain curves of various yarns which was applied to flax, wool, hemp, ramie, worsted viscose and cotton yarns.

From the character of the terminations of the curves a theory as to the mechanism of yarn fractures is developed. It is suggested that in the case of cotton-yarn fracture, the slipping of the component fibres is a prominent feature, while in flax, ramie and hemp, the breakdown of the bundle of fibres is the chief cause of severance.

Representative "Hysteresis" curves from a linen and a cotton yarn are given and discussed. From a practical point of view it is considered that these curves should give some indication of the probable reaction of the warp to the forces applied to it in the loom.

Elastic properties of yarn, by J. A. Matthew, M.Sc., A.R.C.S. (*Jour. Text. Inst.*, XIII, 2.)

The paper describes a testing machine for the carrying out of accurate work in the elasticity of yarns. The results are largely preliminary and of a qualitative nature and a further quantitative examination of "Hysteresis" diagrams is promised.

Measurement of breaking stresses, extensibilities and elasticities of single fibres of cotton, etc., by T. Barratt, D.Sc., of the Tootal Broadhurst Lee Co. Ltd. Laboratories. (*Jour. Text. Inst.* XIII, 1, Trans.)

A description of an accurate method of determining the stress-strain diagram of cotton and similar fibres, the pull being applied by a solenoid and thus not only measurable and controllable but applied gradually and without jerks. The tensile strength of (Egyptian) cotton fibre is stated to be $2{\cdot}4 \times 10^9$ dynes per sq. cm. as compared to 15×10^9 dynes per sq. cm. for steel. The elasticity of (Egyptian) cotton fibre is given as $0{\cdot}8 \times 10''$ C.G.S. units

as compared to $5 \times 10''$ C.G.S. units for quartz and $12 \times 10''$ units for cast iron.

THE CHEMICAL CONSTITUENTS OF RAW COTTON, by Dr. R. G. FARGHER and Dr. J. C. WITHERS, of the British Cotton Industry Research Association. (*Jour. Text. Inst.*, XIII, 1, Trans.)

This paper gives an excellent résumé of work from 1829 onwards on the chemical constitution of cotton and is accompanied by an excellent lithography. Little is known yet of the effect of the minor constituents of raw cotton in spinning and manufacture. It is generally agreed that the *waxes* become soft and semi-liquid at spinning room temperature, thus allowing the proper working of the cotton, and that after spinning the wax sets and cements the fibres. Knecht has shown that Egyptian cotton deprived of its waxes spins badly.

THE REGULARITY OF SINGLE YARNS AND ITS RELATION TO TENSILE STRENGTH AND TWIST, by Dr. A. E. OXLEY. (*Jour. Text. Inst.*, XIII, Trans., 3rd March, 1922.)

The paper describes method for photographing continuously any length of yarn under high magnification, a detailed series of tensile strength tests of three-inch lengths. The effect of added and diminished test on the strength of yarns is then discussed and the author proceeds to an analysis of the results obtained in relation to the mechanism of the mule and ring frame.

The methods used and the results obtained are not only of interest to spinners and weavers but to all who are concerned in the interpretation of spinning tests.

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COTTON-GROWING PROSPECTS IN CEYLON.

SOME time ago Mr. B. Horsburgh, then Government Agent of the Northern Province, drew the attention of the Director of Agriculture to the existence in the Mannar District of what appeared to be "black cotton soil." The Director sent samples of the soil to the Government Agricultural Chemist for analysis and report, and ordered the divisional agricultural officer to report upon cotton-growing prospects in the area.

The reports of the two officers show that the "black cotton soil," which covers some 16 square miles, is equal to the cotton soil of the Madras Presidency, and the lesser cotton soils of America, that the place is free from malarial fever during the greater part of the year, that the average annual rainfall of about 40 inches, chiefly registered between October and December, is favourable for cotton-growing, that motor tractors might be employed to trim the land, that cattle might be raised with advantage to work the land for crops in general and that the water supply is satisfactory, there being five small tanks, two of which are now used for paddy cultivation. Against these advantages have to be set the very unsatisfactory road conditions to Mankulam, the nearest railway station, which is some 14½ miles away. This might, however, be remedied by laying trolly or ærial-tramway lines to transport produce. The local labour supply is meagre, so that labour would have to be introduced, and the possibilities of damage to crops by pests and by wild animals must be taken into account.

It is estimated that working 10,000 acres on a two-year rotation basis, or laying out half the whole area under cotton at a time, 1,500,000 lb. of cotton could be obtained from each crop.

The divisional agricultural officer of the Southern Division planted during the Christmas rainy period 10 acres at Kiula and 50 acres at Ambalantota, with Cambodia, Egyptian, American, Upland, Sea Island, and Indian cotton. Upon the result of these experiments will depend the extension of the cotton-growing area in the Tangalla and Hambantota districts.

Some Indian and Cambodia cotton seed was distributed among villagers in the Southern Agricultural Division some time ago. The Ceylon Government has in hand Rs. 5,000 to purchase the resulting crop of seed-cotton at a fixed price of 20c. per lb. [*The Times Trade Supplement*, 4th March, 1922.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WE deeply regret to have to record the death of Mr. R. C. T. Petty, B.A., Assistant Agricultural Bacteriologist, Pusa, which occurred on 15th March, 1922. The late Mr. Petty joined the Indian Agricultural Service in November 1921, and was 26 years old at the time of his death. We offer our heart-felt sympathy with his parents.

MR. W. A. DAVIS, B.Sc., A.C.G.I., Indigo Research Chemist, Pusa, is granted privilege leave for 13 days from 11th April, 1922, and is also granted permission to terminate his engagement with the Government of India on the expiry of such leave.

***

MR. WYNNE SAYER, B.A., Secretary, Sugar Bureau, Pusa, has been granted combined leave for eight months from 23rd March, 1922, Rao Saheb Kasanji D. Naik, M.A., officiating.

***

DR. J. SEN, M.A., Supernumerary Agricultural Chemist, Pusa, was on leave for one month and nine days from 4th March, 1922.

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THE degree of Doctor of Science (Aberdeen University) has been conferred on Mr. G. P. Hector, Economic Botanist to the Government of Bengal.

Col. A. Smith, M.R.C.V.S., Principal, Bengal Veterinary College, and Veterinary Adviser to the Government of Bengal, has been allowed leave for five months combined with the annual vacation.

***

Mr. V. G. Gokhale, L.Ag., has been confirmed in the appointment of Deputy Director of Agriculture, Konkan, with effect from the 5th September, 1915, on which date the lien of Mr. V. H. Naik was removed.

***

Mr. E. S. Farbrother, M.R.C.V.S., on return from leave, has been appointed Superintendent, Civil Veterinary Department, Bombay.

***

Mr. Saadat-ul-lah Khan, Probationary Deputy Director of Agriculture, Madras, was on leave on half average pay for three weeks from 5th April, 1922.

***

Mr. R. C. Wood, M.A., Principal, Agricultural College, Coimbatore, is permitted to take employment under the Empire Cotton Growing Corporation.

***

Dr. R. V. Norris, Government Agricultural Chemist, Madras, has been appointed to act as Principal, Agricultural College, Coimbatore, in addition to his own duties, until further orders.

***

Mr. D. G. Munro, Assistant to the Principal, Agricultural College, Coimbatore, has been appointed to act as Superintendent, Central Farm, Coimbatore, until further orders.

***

Mr. D. A. D. Aitchison, M.R.C.V.S., Principal, Madras Veterinary College, has been granted leave for four months in continuation of the college vacation.

Dr. H. M. Leake, on completion of special duty for cotton work at Cawnpore, has resumed charge of his duties as Director of Agriculture, United Provinces.

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Mr. G. Clarke, A.C.G.I., on being relieved of the duties of the Director of Agriculture, has reverted as Agricultural Chemist to Government, United Provinces.

***

Mr. W. N. Harvey, Deputy Director of Agriculture, North-Eastern Circle, United Provinces, has been granted combined leave for one year, five months and six days, Dr. T. M. Singh, Assistant Agricultural Chemist, officiating.

***

Dr. A. E. Parr, Deputy Director of Agriculture, Western Circle, United Provinces, has been granted combined leave for six months, Rai Sahib Ganga Prasad officiating.

***

The eight months' combined leave granted to Mr. B. H. Wilsdon, B.A., Agricultural Chemist to Government, Punjab, has been extended by furlough for six months.

***

Sardar Sahib Kharak Singh, Maulvi Fateh-ud-din and Chaudhuri Mahomed Abdullah, of the Punjab Agricultural Service, have been promoted to the Indian Agricultural Service.

***

Lt.-Col. G. K. Walker, C.I.E., O.B.E., Principal of the Punjab Veterinary College, Lahore, has been granted combined leave for four months and eighteen days, Mr. W. Taylor, M.R.C.V.S., officiating.

***

Mr. T. F. Quirke, M.R.C.V.S. (Punjab), and Mr. J. S. Garewal, M.R.C.V.S. (N.W.F.P.), have been confirmed in the Indian Civil Veterinary Department.

On his reversion from deputation to the Kapurthala State, Mr. D. R. Sethi, M.A., B.Sc., has been posted as Deputy Director of Agriculture, Orissa.

***

Mr. S. K. Basu, M.A., Assistant Professor of Mycology, has been appointed to act as Economic Botanist, Bihar and Orissa.

***

Mr. G. C. Sherrard, B.A., Professor of Agriculture, Sabour, has been appointed Deputy Director of Agriculture, Patna Circle, Bihar and Orissa.

***

Mr. N. S. McGowan, B.A., Deputy Director of Agriculture, Bhagalpur Circle, Bihar and Orissa, has been appointed Professor of Agriculture, Sabour.

***

Mr. D. Quinlan, M.R.C.V.S., Director of the Civil Veterinary Department, Bihar and Orissa, has been granted a further extension of furlough on medical certificate for two months.

***

Mr. A. G. Birt, B.Sc., Deputy Director of Agriculture, Assam, has been granted combined leave for nine months and 26 days.

***

Mr. L. Barthakur has been appointed Deputy Director of Agriculture, Assam Valley, and posted to Jorhat.

Reviews

The Bases of Agricultural Practice and Economics in the United Provinces, India.—By H. MARTIN LEAKE, M.A., Sc.D., F.L.S., Director of Agriculture, United Provinces. (Cambridge: W. Heffer & Sons, Ltd.) Price, 15*s*. net.

So rarely does an agriculturist write on the economic aspect of his subject or attempt to treat of "fundamentals" that Dr. Martin Leake's book on that account alone deserves to be widely read.

As an introduction to the subject of rural economics the book is admirable both from its wide outlook and simplicity of treatment, and it is hoped that its publication at an opportune moment, when the subject is attracting considerable attention, will assist towards a more intelligent view of the present position of agriculture in India and the directions in which improvement is more likely to be effected.

The opening chapters consist of a general historical sketch of the early stages of agriculture, its development in response to the demands of an ever-increasing population, and the effects upon it of various external influences, more especially that of the improvement of communications. In Part II—the basis of agricultural practice—a short account is given of the more important conditions—controllable and the reverse—affecting plants and crops, of limiting factors and diseases, all of which play an important part in determining the character of the agriculture of different localities. Part III contains a short discussion on the fundamental conceptions of wealth and value, supply and demand, ownership of land, labour and capital. The latter part of the book deals with rural development in which the author for the sake of convenience divides the subject into the development of agricultural practice and

agricultural economics and finishes with a short chapter on the economic aspect of cattle in which the views expressed appear to be particularly sound. The problem of the cattle in the United Provinces, as in other parts of India, is bound up intimately with that of fodder production, and in the closely settled districts the only real hope of any great advance on existing conditions lies in the improvement of the irrigation water supply. Egypt is quoted as a country in which the question has been settled by the growing of catch crops made possible through irrigation. The author, however, expresses doubt that in the eastern parts of his province the sub-division of holdings has gone too far to make even irrigation a solution to the problem.

The above brief sketch of the contents of the book gives a very inadequate idea of its real value as a thoughtful contribution to the subject. As stated in the text, India is a country in which the development of agriculture can be studied in all the stages of its growth. The author, however, does not fail to convey the impression, intentionally or otherwise, that the most urgent problems or at least the most pressing evils exist in the more advanced stages of the development of the community and are the results chiefly of over-population. These evils are undue sub-division of holdings, rack renting and usury which have gradually transformed the cultivator from a state of independence to one of practical serfdom from which no purely agricultural improvement can rescue him. The cure lies in co-operative organization, but it is again doubtful whether voluntary co-operation can proceed very far with an illiterate population.

The improvement of primary education would thus appear to be a fundamental condition to real agricultural improvement. [S. M.]

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Bird Friends and Foes of the Farmer.—By P. SUSAINATHAN, F. E. S. (*Madras Department of Agriculture Bulletin* No. 81, Illus.). Price, R. 1-6.

MR. P. SUSAINATHAN has for many years devoted a good deal of his time to the observation of bird life, and I strongly recommend

an intelligent perusal of this Bulletin to all officers of the agricultural section. It is unnecessary to emphasize the extent to which birds affect all those engaged in farming : but apart from their importance to the agriculturist in this respect they are of absorbing interest in themselves. We all need recreation of some kind, and from personal experience I can guarantee many pleasant and interesting hours to those who take up the study of birds and their ways. Those whose work carries them out into the districts should have many opportunities for noting nesting and feeding habits and the many other activities of birds, and all such observations made of birds in their natural surroundings are of value. The observer must, however, be certain of the bird whose ways he is noting ; this Bulletin will enable him to do so. [E. B.]

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The Extension of Cotton Cultivation in Tanganyika Territory.—By Major HASTINGS HORNE. (Empire Cotton Growing Corporation.)

THIS is a report on a tour taken in November 1920—July 1921, and reviews the possibilities of cotton growing in Tanganyika. It is stated that the Morogoro-Kilossa area which is served by the Central Railway could be expected to yield 20,000 bales at an early date. This tract has already produced cotton which has been favourably reported on in Manchester. The Lake Basin area is also promising.

The coastal belt has the advantages of easy transport and excellent soil, but a sparse population and the prevalence of malaria are drawbacks.

Irrigation from rivers and streams is feasible in many parts of the Morogoro-Kilossa area.

It is estimated that 7,500 bales were produced in 1921 but that this is only a small fraction of what could be expected with active encouragement, an adequate agricultural department and some assistance in marketing. An appendix gives some interesting results from some of the (pre-war) German experimental farms. Both Egyptian and American varieties did well, Nyasaland Upland being the best yielder.

It is stated that Morogoro territory already possesses an excellent cotton of its own, of the American Upland type but with staple $1\frac{1}{8}''$ to $1\frac{1}{4}''$ and even longer. It seems probable that the improvement of this cotton now irregular in staple by selection is all that is necessary. Importation of seed is deprecated on account of the risk of introducing pests from which the country seems at present singularly free. [B. C. B.]

Correspondence

ROYAL SOCIETY OF ARTS.

To

The Editor,

The Agricultural Journal of India.

Sir,

A cable has just come to hand regarding an address given before the Royal Society of Arts on the "Economic Advantages of Indian Timber." This is just an example of the good work which the Royal Society is doing in England.

The following information may be interesting to those of your readers not already Fellows of the Society.

The Society was founded in 1754, and incorporated by Royal Charter in 1874, for "The Encouragement of the Arts, Manufactures and Commerce of the country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works of the various departments of the Fine Arts; for Discoveries, Inventions and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for application of such natural and artificial products, whether Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application in every department of science in connection with the Arts, Manufactures, and Commerce of this country." In 1908, the Society was granted the privilege of adding "Royal" to its title.

I have been asked by the Secretary to forward a leaflet giving details of the Society's work to those who are interested. I shall be happy to do this on application.

Grand Hotel,
Calcutta.

Yours faithfully,
W. T. Day,
Hon. Press Secretary.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

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1. HEREDITY, by the late L. Doncaster, Sc.D., F.R.S. Third Edition, Revised. Cambridge Manuals of Science and Literature. (Cambridge University Press.) Price, 4*s*. net.
2. English Farming, Past and Present, by the Right Hon'ble Lord Ernle (Rowland E. Prothero). Third Edition. (London: Messrs. Longmans, Green & Co.) Price, 12*s*. 6*d*.
3. Mendelism, by Reginald C. Punnett, F.R.S. Sixth Edition. (London : Macmillan & Co., Ltd.) Price, 8*s*. 6*d*. net.
4. Strasburger's Text-book of Botany. Fifth English Edition. Revised with the fourteenth German Edition, by W. H. Lang. With 833 Illustrations. (London : Macmillan & Co., Ltd.) Price, 31*s*. 6*d*. net.
5. Mathematics for Students of Agriculture, by Samuel E. Rasor. (London : Macmillan & Co., Ltd.) Price, 16*s*. net.
6. The Manufacture of Chemical Manures, by J. Fritsch. Second English Edition. (London : Scott, Greenwood & Son.) Price, 15*s*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoir.

1. Correlation of Colour Characters in Rice, by G. P. Hector, M.A., B.Sc. (Botanical Series, Vol. XI, No. 7.) Price R. 1-4 or 1*s*. 8*d*

Bulletins.

2. The Weevil Fauna of South India with special reference to species of Economic Importance, by T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S. (Bulletin No. 125.) Price, R. 1-4.

3. Cawnpore-American Cotton, II. Further Field Trials (1918-20), Spinning Trials and Market Organization, by B. C. Burt, M.B.E., B.Sc. (Bulletin No. 126.) Price, As. 4.
4. Coconut Bleeding Disease, by S. Sunderaraman, M.A. (Bulletin No. 127.) Price, As. 8.
5. Preparation of Anti-rinderpest Serum using Animals of moderate susceptibility as Virus Producers. Part I—Buffaloes, by W. A. Pool, M.R.C.V.S., and T. M. Doyle, F.R.C.V.S. (Bulletin No. 129.) Price, As. 12.

Report.

6. Proceedings of the Board of Agriculture in India, held at Pusa on the 13th February, 1922, and following days (with appendices). Price, R. 1.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st AUGUST 1921 TO 31st JANUARY 1922.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultaral Journal of India*, Vol. XVI, Parts V & VI, and Vol. XVII, Part 1. Price R. 1-8 or 2*s*. per part; annual subscription Rs. 6 or 9*s*. 6*d*.	Edited by the Agricultural Adviser to the Government of India.	Messrs. Thacker, Spink & Co., Calcutta.
2	Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau) for 1920-21. Price R. 1-8.	Issued from the Agricultural Research Institute, Pusa.	Government Printing, India, Calcutta.
3	Review of Agricultural Operations in India, 1920-21. Price R. 1-4.	Agricultural Adviser to the Government of India, Pusa.	Ditto
4	Experiments with Castor Seed conducted at Sabour. Pusa Agricultural Research Institute Bulletin No. 117. Price As. 3.	C. Somers Taylor, B.A., Agricultural Chemist, Bihar and Orissa.	Ditto
5	The Agricultural Development of Baluchistan. Pusa Agricultural Research Institute Bulletin No. 119. Price As. 6.	Albert Howard, C.I.E., M.A., Imperial Economic Botanist, and Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist.	Ditto
6	Pusa 12 and Pusa 4 in the Central Circle of the United Provinces. Pusa Agricultural Research Institute Bulletin No. 122. Price As. 11.	B. C. Burt, M.B.E., B.SC., F.C.S., Deputy Director of Agriculture, Central Circle, United Provinces, Albert Howard, C.I.E., M.A., Imperial Economic Botanist, and Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
7	The Bundelkhand Cottons, Experiments in their Improvement by Pure Line Selection. Pusa Agricultural Research Institute Bulletin No. 123. Price As. 4.	B. C. Burt, M.B.E., B.Sc., F.C.S., Deputy Director of Agriculture, Central Circle, United Provinces, and Nizamuddin Hyder, Subordinate Agricultural Service, United Provinces.	Government Printing, India, Calcutta.
8	Safflower Oil. Pusa Agricultural Research Institute Bulletin No. 124. Price As. 4.	Albert Howard, C.I.E., M.A., Imperial Economic Botanist, and J. Stewart Remington, Consulting Chemist, Aynsome Technical Laboratories, Grange-over-Sands, Lancashire.	Ditto
9	Estimates of Principal Crops in India, 1920-21. Price one-half anna.	Issued by the Department of Statistics, India.	Ditto
10	Summary of Tables showing the total area, area cultivated and uncultivated, area under irrigation and area under different crops in British India in the Agricultural year, 1920-21. Price As. 4.	Ditto	Ditto
11	Prices and Wages in India. (Thirty-sixth issue.) Price Rs. 2.	Ditto	Ditto
12	Agricultural Statistics of British India, 1919-20, Vol. I. Price Rs. 2-8.	Ditto	Ditto
13	Estimates of Area and Yield of Principal Crops in India, 1920-21. Price As. 8.	Ditto	Ditto
14	Report on the Operations of the Department of Agriculture, Bengal, for the year 1920-21. Price Rs. 2-4.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Press, Calcutta.
15	Proceedings of the Second Annual Conference of the Board of Agricultural Department, Bengal, held at Dacca, on the 1st and 2nd August, 1921 (for official use only).	Ditto	Ditto
16	*Bengal Agricultural Journal* (quarterly). Vol. I, No. 3. (In English and Bengali.) Annual subscription R. 1-4, single copy As. 5.	Ditto	Sreenath Press, Dacca.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
17	Annual Report of the Department of Agriculture, Bihar and Orissa, for the year ending 30th June, 1921. Price As. 8.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.
18	Agricultural Statistics of Bihar and Orissa for 1920-21.	Ditto	Ditto
19	Report on the Administration of the Department of Agriculture of the United Provinces for the year ending 30th June, 1921. Price R. 1-2.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
20	Season and Crop Report of the United Provinces of Agra and Oudh for 1920-21. Price As. 12.	Ditto	Ditto
21	Report on the Agricultural Stations in the Central Circle, United Provinces, for the year ending 30th June, 1921. Price R. 1.	Ditto	Ditto
22	Report on the Agricultural Stations of the Western Circle, United Provinces, for the year ending 31st May, 1921. Price. R. 1-10.	Ditto	Ditto
23	Report on the Agricultural Stations in the North-Eastern Circle, United Provinces, for the year ending 30th June, 1921. Price As. 4.	Ditto	Ditto
24	Report on the Agricultural Stations in the Eastern Circle, United Provinces, for the year ending 30th June, 1921. Price As. 14.	Ditto	Ditto
25	Report on Government Botanical Gardens, United Provinces, Saharanpur, for the year ending 31st March, 1921.	Ditto	Ditto
26	Report on Government Horticultural Gardens, United Provinces, Lucknow, for the year ending 31st March, 1921. Price As. 3.	Ditto	Ditto
27	Annual Report of the Kumaun Government Gardens for the year 1920-21. Price As. 4.	Commissioner of Kumaun Division.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
28	Annual Report of the Chaubattia and Sitoli Orchards for the year 1920-21. Price As. 4.	Commissioner of Kumaun Division.	Government Press, United Provinces, Allahabad.
29	Annual Report of the Department of Agriculture, Punjab, for the year 1920-21, Part I. Price As. 8.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
30	Annual Report of the Department of Agriculture, Punjab, for the year 1919-20, Part II (Annual Experiment Record). Price Rs. 4-8.	Ditto	Ditto
31	Season and Crop Report of the Punjab for 1920-21. Price R. 1-6.	Ditto	Ditto
32	Annual Report of the Lawrence Gardens, Lahore, for 1920-21. Price As. 2.	Ditto	Ditto
33	Tables of Agricultural Statistics of the Punjab for the year 1920-21.	Ditto	Ditto
34	Annual Report of the Department of Agriculture, Bombay Presidency, for 1920-21.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press. Poona.
35	Season and Crop Report of the Bombay Presidency for 1920-21. Price As. 9-6.	Ditto	Government Central Press, Bombay.
36	Rice cultivation in the Larkana District, Sind. Bombay Department of Agriculture Bulletin No. 99. Price As. 8.	Abdul Rahman Ishaq, L.Ag., Acting Divisional Superintendent of Agriculture, Sind.	Ditto
37	Fodder Crops of Western India. Bombay Department of Agriculture Bulletin No. 100. Price Rs. 2-1.	Harold H. Mann, D.Sc., Acting Director of Agriculture, Bombay Presidency, Poona.	Ditto
38	Fruit culture in Palitana and Jamnagar. Bombay Department of Agriculture Bulletin No. 101. Price As. 8-6.	G. B. Patwardhan, B.Sc., F.R.H.S., Assistant Professor of Botany, Agricultural College, Poona.	Ditto
39	Investigations on Potato cultivation in Western India. Bombay Department of Agriculture Bulletin No. 102. Price R. 1-15.	H. H. Mann, D.Sc., S. D. Nagpurkar, B.Ag., G. S. Kulkarni, M.Ag., R. S. Kasargode, L.Ag., S. R. Paranjpe, M.Ag., and H. M. Joshi, B.Sc.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
40	Book of Mango. Bombay Department of Agriculture Bulletin No. 103. Price Rs. 3-5.	W. Burns, D.sc. (Edin.) Economic Botanist to the Government of Bombay, and S. H. Prayag, M.Ag. (Bombay), Department of Agriculture, Bombay.	Government Central Press, Bombay.
41	Ganeshkhind Botanical Garden, Kirkee (Its Genesis and Development). Bombay Department of Agriculture Bulletin No. 104. Price As. 15-6.	S. H. Prayag, M.Ag. (Bombay), Department of Agriculture, Bombay.	Ditto
42	Dharwar-American Cotton, its history, cultivation and improvement. Bombay Department of Agriculture Bulletin No. 106. Price As. 7.	G. L. Kottur, B.Ag., Cotton Supervisor, Dharwar.	Yeravda Prison Press, Poona.
43	Gonag: A Weed in Drilled Paddy. Bombay Department of Agriculture Bulletin No. 107. Price As. 5.	S. S. Salimath, B.Ag., Inspector of Agriculture, Dharwar.	Ditto
44	Summary of the work done at Jalgaon Farm. Bombay Department of Agriculture Bulletin No. 108. Price As. 5-6.	P. C. Patil, L.Ag., Deputy Director of Agriculture, Central Division.	Ditto
45	Report on the Operations of the Department of Agriculture, Madras Presidency, for 1920-21.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
46	Season and Crop Report of Madras for 1920-21. Price R. 1.	Ditto	Ditto
47	Year Book of the Madras Agricultural Department, 1920-21. Price As. 10.	Ditto	Ditto
48	A Note on Casuarina plantation in the Vizagapatam District. Madras Department of Agriculture Bulletin No. 82.	G. Jogiraju, Farm Manager.	Ditto
49	Note on Monsoon Plough. Madras Department of Agriculture Leaflet No. 14.	Issued by the Department of Agriculture, Madras.	Ditto
50	Report on the Working of the Department of Agriculture, Central Provinces, for 1920-21. Price R. 1.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Nagpur.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
51	Season and Crop Report of Central Provinces and Berar for 1920-21. Price As. 8.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Nagpur.
52	Return of expenditure on the Provincial and District Gardens in the Central Provinces and Berar for the year ending 30th June, 1921.	Ditto	Ditto
53	The Purchase of Agricultural Implements. Central Provinces Department of Agriculture Bulletin No. 11 (1921).	R. G. Allan, M.A., Principal, Agricultural College, Nagpur.	Ditto
54	Tractors on Indian Farms. Central Provinces Department of Agriculture Bulletin No. 12 (1921).	Ditto	Ditto
55	The Organization of the Department of Agriculture. Central Provinces Department of Agriculture Bulletin No. 13 (1921).	D. Clouston, M.A., D.Sc., C.I.E., Director of Agriculture, Central Provinces.	Ditto
56	Leaflet entitled Note on Manure (Dry-earth system and compost).	Issued by the Department of Agriculture, Central Provinces and Berar.	Ditto
57	Report of the Agricultural Experiments and Demonstrations in Assam for the year ending 31st March, 1921. Price As. 12.	Issued by the Department of Agriculture, Assam.	The Assam Secretariat Printing Office. Shillong
58	Table of Agricultural Statistics of Assam for the year 1920-21.	Ditto	Ditto
59	The Fodder Supply of the Surma Valley. Assam Department of Agriculture Bulletin No. 1 (1921).	Ditto	Ditto
60	Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June, 1921.	Issued by the Department of Agriculture, Burma	Government Printing Office, Burma, Rangoon.
61	Tables of Agricultural Statistics of Upper Burma for 1920-21.	Ditto	Ditto
62	Season and Crop Report of Burma for 1920-21. Price R. 1.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
63	Summary of Remarks on the Kharif Crop of the North-West Frontier Province for 1921. Price As. 9.	Revenue Commissioner, North-West Frontier Province.	Government Press. Peshawar.
64	Report of the Agricultural Stations at Tarnab and Haripur in the North-West Frontier Province for the two years ending 30th June, 1920.	Issued by the Department of Agriculture, North-West Frontier Province.	Ditto
65	Season and Crop Report of North-West Frontier Province for 1920-21 Price R. 1-8-6.	Ditto	Ditto
66	Report on the Operations of the Department of Agriculture and Fisheries, Travancore, for the year 1920-21.	Issued by the Department of Agriculture, Travancore.	Government Press, Trivandrum.
67	Annual Report of the Agricultural Department, Gwalior State, for 1920-21.	Issued by the Department of Agriculture, Gwalior.	Alijah Darbar Press, Lashkar.
68	Report on the Administration of Avenues, Public Gardens, Fisheries and Agricultural Department in the Cochin State for 1906 (1920-21).	Issued by the Department of Agriculture and Fisheries, Cochin.	Cochin Government Press, Ernakulam
69	*The Journal of the Madras Agricultural Students' Union* (monthly). Annual subscription Rs. 2.	Madras Agricultural Students, Union.	Literary Sun Press, Coimbatore.
70	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
71	*Poona Agricultural College Magazine* (quarterly). Annual subscription Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
72	*Journal of the Mysore Agricultural and Experimental Union* (quarterly). Annual subscription Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
73	*Indian Scientific Agriculturist.* Annual subscription Rs. 4.	Alliance Advertising Association, Ltd., Calcutta.	Bera & Co., Printers, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	AGRICULTURAL CHEMISTRY.		
74	Investigations on Indian Opium, No. 1. Non-environmental Factors influencing the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*). Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VI, No. 1. Price R. 1-8 or 2*s*.	Harold E. Annett, D.SC. (Lond.) F.I.C., M.S.E.A.C., etc., Agricultural Chemist to the Government of Bengal on special duty at Cawnpore, Haridas Sen, M.SC., and Har Dayal Singh, B.SC.	Messrs. Thacker, Spink & Co., Calcutta.
75	Investigations on Indian Opium, No. 2. The Effect of Environmental Factors on the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*) and the Bearing of the work on the functions of Alkaloids in Plant Life. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VI, No. 2. Price Rs. 2 or 2*s*. 9*d*.	Harold E. Annett, D.SC. (Lond.), F.I.C., M.S.E.A.C., etc., Agricultural Chemist to the Government of Bengal on special duty at Cawnpore.	Ditto
76	Variations in some characteristics of the Fat of Buffalo and Cow Milk with changes in Season and Feeding: the Mutual applicability of the Analytical Figures for Butter, Fat and Ghee. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VI, Nos. 4 & 5. Price As. 12 or 1*s*. 3*d*.	F. J. Plymen, A.C.G.I., Agricultural Chemist to the Government of Central Provinces, and A. R. Padmanabha Aiyer, B.A., Assistant Agricultural Chemist, Central Provinces.	Ditto
	BOTANY.		
77	Studies in Gujarat Cottons, Part I. Memoirs of the Dement of Agriculture in India, Botanical Series, Vol. XI, No. 4. Price Rs. 2 or 2*s*. 6*d*.	Maganlal L. Patel, B.Ag., Cotton Supervisor, Gujarat.	Messrs. Thacker, Spink & Co., Calcutta.
78	The Influence of Atmospheric Conditions upon the Germination of Indian Barley. Memoirs of the Department of Agriculture in India. Botanical Series, Vol. XI, No. 6. Price As. 9 or 1*s*.	W. Youngman, B.SC., Economic Botanist to Government, United Provinces.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		MYCOLOGY.	
79	Die-Back of Chillies (*Capsicum* spp.) in Bihar. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XI, No. 5. Price R. 1 or 1*s*. 4*d*.	Jehangir Fardunji Dastur, M.Sc., Offg. Second Imperial Mycologist	Messrs. Thacker, Spink & Co., Calcutta.
80	Coconut Stem-Bleeding Disease. Leaflet No. 15 of the Madras Department of Agriculture.	S. Sundararaman, M.A., Government Mycologist.	Government Press, Madras.
81	Gwabo Disease of Paddy. Burma Department of Agriculture Bulletin No. 16.	Issued by the Department of Agriculture, Burma.	Government Printing Office, Burma, Rangoon.
82	The Nature and History of Ear-cockle in Wheat and its Treatment. Price As. 2.	D. Milne, B.Sc., Economic Botanist, Punjab.	Government Printing, Punjab, Lahore.
		ENTOMOLOGY.	
83	Life-histories of Indian Insects. Diptera : *Sphryracephala hearseiana,* Westw. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. VII, No. 6. Price As. 12 or 1*s*.	S. K. Sen, B.Sc., Entomological Assistant, Pusa.	Messrs. Thacker, Spink & Co., Calcutta.
84	Annotated List of Indian Crop Pests. Pusa Agricultural Research Institute Bulletin No. 100. Price R. 1-8.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist.	Government Printing, India, Calcutta.
85	Some Insects recently noted as Injurious in South India. Pusa Agricultural Research Institute Bulletin No. 101. Price As. 8.	T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., Acting Government Entomologist, Madras.	Ditto
86	Borers in Sugarcane, Rice, etc. Pusa Agricultural Research Institute Bulletin No. 102. Price R. 1.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist.	Ditto
87	Some Indian Economic Aleyrodidæ. Pusa Agricultural Research Institute Bulletin No. 103. Price As. 8	C. S. Misra, B.A., First Assistant to Imperial Entomologist.	Ditto
88	The Rice Leaf-hoppers. Pusa Agricultural Research Institute Bulletin No. 104. Price As. 6.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Entomology—contd.		
89	The Pink Bollworm in Egypt. Pusa Agricultural Research Institute Bulletin No. 106. Price Re. 1.	Lewis H. Gough, Ph.D., F.E.S., Director of the Entomological Service, Ministry of Agriculture, Egypt.	Government Printing, India, Calcutta
90	Some Pests of Cotton in North Bihar. Pusa Agricultural Research Institute Bulletin No. 108. Price As. 6.	C. S. Misra, B.A., First Assistant to Imperial Entomologist.	Ditto
91	*Tukra* Disease of Mulberry. Pusa Agricultural Research Institute Bulletin No. 109. Price As. 4.	Ditto	Ditto
92	Stored Grain Pests. Pusa Agricultural Research Institute Bulletin No. 111. Price As. 14.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, and C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto
93	Notes on Rearing Insects in Hot Climates. Pusa Agricultural Research Institute Bulletin No. 112. Price As. 7.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, and C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto
94	Hints on Collecting and Preserving Insects. Pusa Agricultural Research Institute Bulletin No. 113. Price As. 10.	T. Bainbrigge Fletcher, R.N., F.L.S, F.E.S., F.Z.S., Imperial Entomologist.	Ditto
95	Note on Plant Imports into India. Pusa Agricultural Research Institute Bulletin No. 115. Price As. 7.	Ditto	Ditto
96	Report of the Proceedings of the Fourth Entomological Meeting held at Pusa on the 7th to 12th February, 1921. Price Rs. 7-8.	Edited by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist.	Ditto
97	The Entomologist's Crop Pest Calendar for the Madras Presidency. Madras Department of Agriculture Bulletin No. 80.	T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., Assistant Entomologist, Madras.	Government Press, Madras
98	Bird Friends and Foes of the Farmer. Madras Department of Agriculture Bulletin No. 81.	P. Susainathan, Assistant to Government Entomologist, Madras.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Entomology—concld.		
99	The present state of the Mulberry Silkworm Industry of the Madras Presidency and its possible improvements. Madras Department of Agriculture Leaflet No. 13.	K. T. Achya, Sericultural Expert, Madras.	Government Press Madras.
100	The Groundnut Bug and its Control. Bombay Department of Agriculture Bulletin No. 105. Price As. 2.	R. S. Kasargode, L.Ag., Assistant Professor of Entomology, Poona Agricultural College, and V. G. Deshpande, B.Ag., Assistant Entomologist, Konkan.	Yeravda Prison Press, Poona.
101	Some Citrus Pests in the Nagpur District. Central Provinces Department of Agriculture Bulletin No. 11.	J. L. Khare, Lecturer in Entomology, Agricultural College, Nagpur.	Government Press Nagpur.
102	Instructions on Bee-keeping. Burma Department of Agriculture Bulletin No. 17.	Issued by the Department of Agriculture, Burma.	Government Printing Office, Burma, Rangoon.
	VETERINARY.		
103	Annual Report of the Imperial Bacteriological Laboratory, Muktesar, for the year ending 31st March, 1921. Price As. 7.	Director and First Bacteriologist, Imperial Bacteriological Laboratory, Muktesar.	Government Printing, India, Calcutta.
104	The Serum Simultaneous Method of Inoculation against Rinderpest. Pusa Agricultural Research Institute Bulletin No. 120. Price As. 2.	W. A. Pool, M.R.C.V.S., Offg. Director and First Bacteriologist, Imperial Bacteriological Laboratory, Muktesar.	Ditto
105	Notes on Contagious Abortion in Pony and Donkey Mares. Pusa Agricultural Research Institute Bulletin No. 121. Price As. 5.	R. Branford, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar, and T. M. Doyle, F.R.C.V.S., Veterinary Officer, Imperial Bacteriological Laboratory, Muktesar.	Ditto
106	Statistics compiled by the Government of India from the Reports of Provincial Civil Veterinary Departments for the year 1919-20.	Issued by the Revenue and Agriculture Department of the Government of India.	G. M. Press, Simla
107	Annual Report of the Civil Veterinary Department, Bihar and Orissa, for the year 1920-21. Price R. 1-10.	Issued by the Civil Veterinary Department, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Veterinary—contd.		
108	A Note on the origin and development of the Civil Veterinary Department, Bihar and Orissa	Captain P. B. Riley, M.R.C.V.S., Offg. Director, Civil Veterinary Department, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.
109	Annual Report of the Civil Veterinary Department, United Provinces, for the year ending 31st March, 1921. Price R. 1-2.	Issued by the Civil Veterinary Department, United Provinces.	Government Press, United Provinces, Allahabad.
110	Annual Report of the Punjab Veterinary College, Civil Veterinary Department, Punjab, and the Government Cattle Farm, Hissar, for the year 1920-21. Price As. 12.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
111	Annual Report of the Camel Specialist for 1920–21. Price As. 2.	Ditto	Ditto
112	List of Horse and Cattle Fairs and Shows in the Punjab and Native States during 1921-22.	Ditto	Ditto
113	The Treatment of Surra in Camels by Tartar Emetic. Punjab Veterinary Bulletin No. 2 of 1920. Price As. 3.	H. E. Cross, M.R.C.V.S., Camel Specialist, Punjab.	Ditto
114	Spirochætosis of Fowls. Punjab Veterinary Bulletin No. 2 of 1921 (English and Vernacular).	Ditto	Ditto
115	Hypoderma Larvæ in Goats. Punjab Veterinary Bulletin No. 3 of 1921 (English and Vernacular).	Ditto	Ditto
116	Recurrent Orchitis in Donkey Colts. Punjab Veterinary Bulletin No. 4 of 1921.	Ditto	Ditto
117	Transmission of Surra by Ticks. Punjab Veterinary Bulletin No. 6 of 1921.	Ditto	Ditto
118	Prospectus of Punjab Veterinary College, Lahore. Price As. 3.	Issued by the Department of Agriculture, Punjab.	Ditto
119	Syllabus of Lectures for the Diploma Course at the Punjab Veterinary College, Lahore. Price As. 2.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title	Author	Where published
	Veterinary.—concld.		
120	Annual Administration Report of the Civil Veterinary Department, Bombay Presidency, for the year 1920-21.	Issued by the Civil Veterinary Department, Bombay.	Government Central Press, Bombay.
121	Report on the working of the Civil Veterinary Department of the Central Provinces and Berar during the year 1920-21. Price R. 1.	Issued by the Department of Agriculture, Central Provinces.	Government Press, Nagpur.
122	Report of the Civil Veterinary Department, Assam, for the year 1920-21. Price As. 8.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
123	Report on the Civil Veterinary Department (including the Insein Veterinary School), Burma, for the year ending 31st March, 1921.	Issued by the Civil Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
124	Report of the Civil Veterinary Department, North-West Frontier Province, for 1920-21. Price As. 13.	Issued by the Civil Veterinary Department, North-West Frontier Province and North Punjab.	Government Press, Peshawar.

THE BENGAL RED VENTED BULBUL

Original Articles

SOME COMMON INDIAN BIRDS.

No. 16. THE BENGAL RED-VENTED BULBUL (*MOLPASTES HÆMORRHOUS BENGALENSIS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

WITH regard to their popular names which are so well known and firmly established that it is difficult to dislodge them from general use, many animals have acquired titles which are perhaps more descriptive than correct. Such, for example, are the "white ant," which is not an ant and not always white, and the "black beetle," which is not a beetle and not necessarily as black as the popular idea paints it. Many similar instances might be quoted and in this connection it is difficult to resist the temptation to refer to the dictionary which defined a lobster as "a little red fish which runs sideways"; whereas of course a lobster is not a fish, it is not red until it has been boiled, and it does not run sideways. Owing to a similar confusion of ideas or terms the Indian Bulbuls have achieved a somewhat spurious reputation as exquisite birds of song. Both in Eastern and in European poetry the bulbul is frequently referred to as a delightful singing bird, and the dweller in India may

well wonder why the Indian Bulbul does not live up to its reputation. The fact seems to be that Indian Bulbul is not the same bird as the bulbul referred to in Persian poetry as the lover of the rose and which is really a nightingale. Our Indian bulbuls have cheerful notes but they are not exactly nightingales.

According to the " Fauna " volume on Birds, some fifty bulbuls are found within Indian limits, of which nine species belong to the genus *Molpastes*. The first six of these, however, are now usually placed together as representing a single species, *Molpastes hæmorrhous*, divided into several geographical races, of which *Molpastes hæmorrhous hæmorrhous* is found in Ceylon and Southern India to about 20° North latitude; *Molpastes hæmorrhous pallidus* takes its place north of this latitude and extends to Bihar and Western Bengal, Rewah, Cutch, etc.; *Molpastes hæmorrhous burmanicus* is found from Manipur to Burma, southwards to Rangoon and eastwards to the Sittoung River; *Molpastes hæmorrhous nigripileus* occurs east of the Sittoung River in South Burma to the Malay Peninsula; *Molpastes hæmorrhous chrysorrhoides* is found in the Kachin Hills, Shan States, and North-East Tenasserim, extending into China; *Molpastes hæmorrhous bengalensis* occurs in the Himalayas, from Kumaun eastwards to Eastern Assam, in North Bihar and Eastern Bengal; and *Molpastes hæmorrhous intermedius* is the race found in the Punjab, North-West Frontier, North Oudh and North-Western Himalayas. In some localities these races run into one another and it seems unnecessary to dilate further on the distinctions between them. The bird shown in our Plate, about half as large again as a sparrow, but with a longer tail, a pointed black crest on its head, and a patch of red feathers beneath its tail, is sufficiently familiar not to require a long description, and may reasonably be set down as a Red-vented Bulbul in one of its numerous forms. It is merely necessary to point out that in other parts of India the local form of this bird may differ slightly from our Plate in the definition or extension of the black on the crown of the head, in the colour of the ear-coverts, chin, or throat, although it always retains the blood-red patch " in the seat of its trousers," as the inimitable EHA so well put it.

These birds are more often found in gardens than in the open country and usually occur in pairs, although sometimes parties of half-a-dozen or more may be seen together. They frequent trees and bushes and are rarely seen on the ground, for progress on which their short legs are not adapted. In the evening they often take up a perch on a twig at the top of a low tree and thence make short upward flights into the air, returning again to the same perch; Cunningham states that such flights "at first suggest the pursuit of some flying insect, but . . . in reality (are) merely the expression of exuberant nervous energy that is worked off by active exercise and the utterance of pleasant little songs." This may be so at times, but I incline to think that the capture of supper in the shape of some small insect on the wing is usually the object of these short flights, as many small insects are flying at that time and other birds, such as drongos, may be seen catching them at the same time and in the same way, although it is difficult to see what it actually is that they catch. In one of his poems, Sir Edwin Arnold writes of

"The Bulbul, which did chase the jewelled Butterflies,"

and certainly at times the Red-vented Bulbul may be seen to catch and eat butterflies, principally species of *Catopsilia*, and, although its diet is a varied one, insects form a large proportion of it. The late C. W. Mason investigated the stomach-contents of thirty-seven birds at Pusa and found them to contain 129 insects, of which 96 were classed as injurious and 30 as of neutral value. Mr. D'Abreu also at Nagpur found the diet to be a mixture of vegetable matter and insects and observed these birds feeding on long-horned grasshoppers. The vegetable food eaten is largely composed of wild fig fruits at Pusa but is varied according to what is available locally. It is noteworthy that these birds have been credited by several observers with a distinct preference for fruits of a red colour. Cunningham, for instance, says: "Among the fruits that they have a great liking for are those of various gourds, particularly one with beautiful, bright red pulpy fruits" and at Faridpur, in Bengal, this bird has been noted as committing "great havoc in gardens amongst tomatos and chillies, the red colour of which seems to

attract them." *Lantana* berries form another class of food of which they are exceedingly fond and the bird shown in our Plate is depicted sitting on a *Lantana* bush, and in districts in which *Lantana* occurs as a pestilential weed its spread is helped very considerably by the dispersal of the seeds eaten by bulbuls. Bulbuls sometimes do some damage by attacking fruits in gardens and orchards, but the good done by destroying insects throughout the whole year must be offset against this.

The nesting-season varies considerably according to locality, as might be expected in the case of a bird so widely distributed, but in the Plains it breeds chiefly in May, June and July, although a few eggs may be found earlier or later. In Southern India the period is about three months earlier than in the North. The nest, which is placed in almost any sort of tree or bush, is neatly cup-shaped and usually composed of dry grass-stems, very small twigs or stems of small plants, lined internally with fine roots or grass or hairs. Spiders-web is sometimes woven into the outside of the nest. Three eggs are usually laid, but sometimes four are found. The egg varies considerably in size, from about 20 to 27 mm. in length, and from about 15 to 19 mm. in breadth, and is pinkish or reddish white, blotched, streaked or speckled with various shades of red, brownish or purplish red.

The bulbul is comparatively an easy bird to keep in confinement, as its diet is a mixed one. It is often kept as a pet by Indians and it is not unusual to meet a proud owner going for a stroll, carrying a bulbul on a little crutched stick which, in the case of wealthy people, is sometimes made of jade or one of the precious metals. We regret to add that one of the attractions of the bulbul as a pet is its ready pugnacity, which is accentuated, when it is desired to make two birds fight, by starving them beforehand and then showing both a morsel of food, whereupon, as a hungry bulbul will naturally resent competition regarding food-supply, a fight is apt to ensue.

AN IMPROVED TYPE OF COTTON FOR THE DHARWAR-AMERICAN TRACT.

BY

G. L. KOTTUR, B.Ag.,

Cotton Breeder, Southern Division, Bombay Presidency.

There are in the Bombay Karnatak two cotton tracts, one of which grows the well-known "Kumpta" type of cotton, while in the other the so-called "Dharwar-American" is chiefly cultivated. The latter lies mainly in the Dharwar District and the adjoining States. This type covers an area of about 400,000 acres annually, with a production of 100,000 bales. Here the rainfall conditions are specially favourable for the cultivation of a variety which grows purely in the *rabi* or winter season. The rains which occur in July and August are often scanty, and this interferes greatly with the timely sowing of Kumpta cotton. The precipitation during the months of September and October is, however, heavy and more regular. The table on next page gives the average rainfall of Dharwar and Gadag, two typical centres, respectively, for growing Kumpta and Dharwar-American cotton.

The Dharwar-American tract thus requires a variety which can be sown as late as September or even October. The climatic conditions, apart from rainfall, which limit the flowering and bolling activities of the cotton plant, are, however, almost the same for the two tracts. This indicates that a cotton variety which can be sown late, but at the same time ripens quickly, is the one best suited for the area in question, and our present day acclimatized American answers both these requirements. This cotton has also other advantages over the indigenous Kumpta variety. For instance, the experience of the cultivators in the Ranebennur and Haveri Talukas of Dharwar seems to indicate

that Dharwar-American is a much less exhausting crop than Kumpta cotton, though we have no experimental proof of this. Further, the bolls of Dharwar-American cotton are big and open well, so that the contents are picked cleaner and with less cost. The outturn and colour of lint are also decidedly superior. The cotton is for these reasons well established in the tract in question, and our efforts are now directed to improve it by selection and crossing.

Month	Average rainfall in inches	
	Dharwar	Gadag
Ante-monsoon rains		
January-April	3·03	2·50
May	2·65	2·20
Total	5·68	4·70
Monsoon rain		
June	4·76	2·83
July	3·89	2·22
August	3·56	2·65
Total	12·21	7·70
Late rain		
September	3·14	6·40
October	5·46	4·93
November-December	2·34	3·22
Total	10·94	14·55
Total for the year	28·83	26·95

The history of Dharwar-American cotton dates from the year 1819 when the Commercial Resident of the Ceded Districts ordered the distribution of New Orleans cotton seeds in Dharwar. Subsequently the East India Company made experimental trials in Dharwar and other districts with a number of foreign cottons of which New Orleans, Upland Georgian, Sea Island and Egyptian were the more important. The results of these trials pointed out the suitability of New Orleans cotton to the conditions of Dharwar, and its cultivation was accordingly taken up by the

cultivators. The cotton soon became very popular in the Dharwar District so that about the year 1860 the area under it actually exceeded that under Kumpta cotton. All the eleven talukas of Dharwar were then growing the new variety but gradually its cultivation extended in the eastern talukas and declined in others. And to-day we see that the cotton has its own tract well defined where the conditions, as already described, are specially favourable to it.

The New Orleans cotton thus acclimatized in Dharwar is known as Dharwar-American or Sawginned-Dharwar. It is, like other cotton varieties, much mixed, containing a large number of different types. The plants may be roughly divided, as regards hairiness on their leaves, into three groups : (1) hairy, (2) sparingly hairy and (3) glabrous. In the same way, the colour of the flower varies on different plants. It may be yellow, sulphur yellow, or white. The dark-coloured eye in the petals is generally absent, but a few individuals produce flowers which possess either a faint or bright eye in them, indicating their Sea Island or Egyptian origin. The crop thus contains a mixture of plants which morphologically differ from one another.

The economic characters also vary in the same way. The number and size of the bolls on individual plants vary much. The percentage of lint differs from plant to plant, and the following table shows the nature of variation in the case of 150 plants taken at random :—

Ginning percentage	Frequency
24	4
25	9
26	15
27	8
28	23
29	33
30	12
31	21
32	5
33	13
34	5
35	2
	150

Similarly the staple varies in length and strength. The variation in length is, however, less marked as is seen from the following table :—

Length of staple in inches	Frequency
0·3	8
0·4	16
0·5	7
0·6	24
0·7	45
0·8	33
0·9	11
1·0	6

But this difference in length is very objectionable. If we take it that all plants with long and short staple yield equally well, then we find that 37 per cent. of the crop is short and 63 per cent. long stapled. This condition of mixture of long and short staple is sure to affect the value of the cotton as long as it exists.

The study of these variations indicates that the cotton affords ample scope for improvement by selection. As already stated, the Dharwar-American cotton enjoys peculiar advantages by virtue of which its cultivation is indispensable in the tract. But it has also certain disadvantages and the one which is serious is its susceptibility to a disease of the leaf known as "red leaf blight." This disease appears very often, causing considerable damage to the crop. It is more severe in certain places than in others; thus American cotton growing at Dharwar always suffers more than at Gadag and it is for this reason the cultivation of that cotton has been given up round about Dharwar, although the cultivators have still a liking for it. Red leaf blight is thus a limiting factor in the cultivation of Dharwar-American cotton which otherwise would have extended over a much larger area.

As already stated, the leaves of Dharwar-American plants are either hairy or glabrous. This fact, it seems, was known to Fletcher when he was working on Dharwar cottons, but we have no record to show that the types were actually separated by him.

Gammie[1] in 1913 thought that deterioration of Dharwar-American cotton was caused by the mixture of these two types and advised their separation to test this view. The types were separated and grown fairly pure but the valuation of lint showed little difference between them for two years. In the meantime the author toured in the Ranebennur Taluka of the Dharwar District and there found out the correlation existing between hairiness and resistance to red leaf blight. Individual selection in the hairy or Upland type was at once started, and a strain possessing many advantages over the ordinary crop was obtained. This strain, which is known as Gadag I, resists the red leaf blight to a remarkable extent, bears big bolls and yields better. There is, moreover, a considerable advantage in its ginning percentage and staple. The following table compares the yield per acre, ginning percentage and value of Gadag I cotton with those of the average ordinary Dharwar-American grown side by side for a number of years on the Gadag farm.

Year	Gadag I			Dharwar-American		
	Yield per acre in lb.		Ginning percentage	Yield per acre in lb.		Ginning percentage
	Kapas	Lint		Kapas	Lint	
1915	264	91	34·5	230	67	29·0
1916	605	200	33·0	530	154	29·0
1917	640	226	35·3	588	176	30·6
1918	484	169	35·0	372	155	31·0
1919	188	62	33·0	98	28	28·2
1920	616	206	33·5	520	146	28·0
AVERAGE ..	466	159	34·0	390	121	29·3

The boll-bearing capacity of Gadag I is almost the same as that of Dharwar-American cotton. Bolls on 1,500 plants were counted and the averge number per plant was 6·275 in the case of Gadag I and 6·255 in the case of ordinary Dharwar-American in a year when there was no attack of red leaf blight. But still the yielding capacity of Gadag I is greater as the bolls are much bigger,

[1] *Report of the Imperial Cotton Specialist*, 1912–13, p. 16.

four bolls of Gadag I being equal to six bolls of ordinary Dharwar-American. In a year when the red leaf blight is severe the glabrous plants in the Dharwar-American crop yield very little and this makes a considerable difference in the yield of the two.

Gadag I is maintained pure by selfing a large number of flowers every year and sowing the selfed seed on the Dharwar farm where there is no fear of deterioration by natural crossing. The produce of this crop is every year supplied to the Gadag seed farm for sowing a large area. The seed of Gadag I cotton is being distributed in the Dharwar-American tract and the cultivators are taking it readily. The local merchants and millowners also appreciate the cotton and give a considerable premium in the price.

The spinning tests made with Gadag I cotton show that the staple is more uniform in length and better in strength. The following is the report of a spinning test made by the Hubli Mills on 1st April, 1921.

Name of cotton	Blow room loss	Count	Test	Remarks
Gadag I	9·75	18·5	74	Quality far superior with regard to uniformity of staple and strength.
General crop of 1920–21 ..	....	30·3	45	

We have thus succeeded in obtaining a better type of cotton for the Dharwar-American tract, but there is little doubt that the staple is capable of further improvement and our attention is now being directed towards this point.

THE IMPROVEMENT OF THE COCONUT *JAGGERY* INDUSTRY ON THE WEST COAST.

(PRELIMINARY COMMUNICATION.)

BY

ROLAND V. NORRIS, D.Sc.,
Government Agricultural Chemist, Madras ;

B. VISVANATH,
Assistant Agricultural Chemist, Madras ;

AND

K. GOVINDAN NAIR, B.A.,
Assistant to the Government Agricultural Chemist, Madras.

On the West Coast in the Malabar District, *jaggery* (unrefined, crude sugar) is manufactured for local consumption from the unfermented juice of the coconut palm. The industry is entirely in the hands of the tapping classes who do not themselves own the trees from which the juice is drawn. In partial return for his work as domestic or garden servant, the owner assigns to the tapper a few trees which the latter taps in his off hours, the juice thus obtained being then handed over to the women of his household for boiling.

Local method of tapping and jaggery making.

The process of tapping is much the same as that carried out with the palmyra palm, the juice being drawn from the inflorescence. Before the spadex matures, this is firmly bound round by the tapper

to prevent it bursting in the later stages. The pointed tip is then cut off and the cut surface and the sides of the spadex thoroughly pounded with a bone or other hard instrument. By this process many of the cells are ruptured and secretion of the juice stimulated. The extent to which this beating process is carried out varies in different localities and with different tappers, and our experience shows that it has a considerable influence on the yield of juice. Thin sections are removed daily from the cut end of the spadex and the beating repeated. After about a fortnight of such treatment the juice begins to flow and this continues until the spadex becomes too short for operations to continue. On an average, a spadex will yield for about six weeks.

The juice is collected, either once or twice daily, in mud pots coated inside with slaked lime. The contents of the pots are then mixed and strained through cloth or a piece of coconut stipule to remove flies, insects and other extraneous matter. Boiling is carried out in mud pots, proceeding simultaneously in two or three pots if the quantity of juice be sufficiently large. When the juice has become more concentrated the contents of the pots are mixed and the final stages carried out in a single vessel. Boiling is continued until the syrup when tested exhibits signs of crystallization. The pot is then removed from the fire and the contents stirred vigorously with a wooden pestle until crystallization commences. The syrup is then poured into moulds made either of shells or strips of coconut leaf and allowed to set.

Thus prepared, the *jaggery* is usually very dark in colour and contains a good deal of foreign matter. It has little keeping power and quickly runs into molasses when stored.

Sugar content of coconut juice.

The juice of the coconut palm when freshly tapped is almost colourless and very pure, the proportion of sugars other than sucrose being considerably less than that found in the juice of the sugarcane. Table I, in which are quoted typical analyses, illustrates this point.

TABLE I.

Sugar content of coconut juice and sugarcane juice.

Coconut			Sugarcane		
Brix	Sucrose per cent.	Glucose per cent.	Brix	Sucrose per cent.	Glucose per cent.
17·04	15·96	0·098	17·69	15·58	1·47
17·42	15·35	0·120	19·47	17·60	1·35
17·17	15·55	0·063	20·07	17·85	0·32
17·18	15·67	0·081	18·89	17·58	0·68
16·40	14·57	0·070	16·66	13·93	1·80
15·98	14·76	0·040	19·09	16·88	1·10

In spite of the clear and colourless nature of the juice, coconut *jaggery* as prepared in the villages is usually considerably darker than that prepared from cane. Its glucose content is, however, as a rule far less than that in the best samples of cane *jaggery*, and yet on the West Coast at any rate, its keeping qualities are inferior to the latter. In consequence of this it sells at a cheaper rate. There is little doubt, however, that if the quality could be improved, the market price would be enhanced and the makers induced to adopt more satisfactory methods of manufacture. That there is much scope for improvement has already been made clear, and, in particular, attention is required in regard to the following points, *viz.*, (*a*) cleanliness, (*b*) colour, and (*c*) keeping quality.

(*a*) *Cleanliness.*

As prepared locally the *jaggery* is far from clean. Few precautions are taken to cover the pots during the collection of juice with the result that insects accumulate and much other foreign matter finds its way into the collecting vessels. As the filtration carried out is crude and inefficient much of the contamination appears also in the finished product. In many cases, in fact, filtration is omitted in order to obviate loss, the maker being more concerned with the quantity of his product than with its quality.

Filtration. It has been found that a perfectly clean and bright juice can be readily obtained by the use of a sand filter. This can be constructed from a tall flower pot having a perforated bottom. The holes in the latter are plugged with coconut fibre which retains the sand while permitting an easy flow of the juice. A layer of about two inches of fine sand is placed in the bottom of the filter and over this a similar layer of coarse sand. On the top of all is placed a piece of coconut stipule which is prevented from floating by means of a piece of tile. The juice is filtered immediately after collection. Coarse impurities and gummy and other substances precipitated by the lime in the collecting vessels are retained by the coarse sand while the finer layer of sand removes the smaller particles of suspended lime, etc. Thus filtered, the juice is clear and bright and the resulting *jaggery* much improved in appearance. *Jaggery* made in this way at the Kasaragod farm was recently exhibited at the Tellicherry Exhibition where it met with the marked approval of local public opinion.

In the process of filtration there is naturally a small amount of loss owing to the retention of juice in the filter. This can be prevented by washing the filter with a small quantity of water, the slight dilution of the juice which results from this operation being of little importance in the district under consideration where the fuel problem does not arise in *jaggery* manufacture, large quantities of coconut dèbris, leaves, etc., being available.

(*b*) *Colour*.

It has already been mentioned that local coconut *jaggery* is usually darker in colour than that prepared from sugarcane in spite of the initially good colour of the juice. The dark colour is chiefly due to the presence of an excess of lime combined with over-heating in the boiling process. Alkalinity, as is well known, results in a considerable destruction of sugar, and the efficient control of the temperature is difficult in the mud pots in which the boiling takes place. Better results can readily be obtained by the use of small copper or iron pans. In the experiments carried out at Kasaragod copper vessels have been employed and the resulting *jaggery* was

eagerly bought up by the people living in the neighbourhood who waited outside the farm while boiling was going on. It must be admitted, however, that copper vessels are probably beyond the reach of the tapper class by whom the industry is carried on. Small iron pans might, however, be employed from which equally good results could be obtained.

The part played by the lime in the formation of colour will be discussed later.

(*c*) *Keeping qualities of jaggery.*

The most important problem in regard to *jaggery* making on the West Coast is its keeping quality, *i.e.*, its ability to remain solid for a reasonable period without running into molasses. In a district where the humidity of the atmosphere is at 100 per cent. saturation for a few months and between 75 to 100 per cent. for practically the rest of the year, it is not possible to keep any *jaggery* for prolonged periods in good condition, but, as will be shown, there is a considerable variation in the behaviour of different samples of *jaggery*, depending on their origin and method of manufacture. Even cane *jaggery* does not keep well unless very carefully packed.

On the West Coast, the usual method of keeping *iaggery* is to wrap the latter in coconut leaves and hang it over the hearth. The point of interest lies in the fact that coconut *jaggery* almost invariably runs into molasses more quickly than cane *jaggery* when preserved under identical conditions. It is, therefore, of great importance to ascertain the reason for this and a method by which the defect may be remedied.

It is a matter of common knowledge that samples of well-limed cane *jaggery* are harder and keep better than samples prepared with less lime, and hence the first obvious step was to investigate the influence of liming on the quality of coconut *jaggery*. The two cases, however, are not quite parallel. In the case of sugarcane the lime is added to the juice after collection and thus the quantity used can readily be regulated and the optimum lime content obtained. In the case of the coconut, however, it is necessary, for excise and other reasons described later, to add the lime to the pots before collecting the juice. We find, however, as the result of

observations extending over several months, that the yield of juice from any particular spadex varies considerably from day to day, with the result that sometimes the juice collected may be greatly over-limed, while on other days when the flow is excessive the amount of lime present may be inadequate. Consequently, normal liming, that is to say, the addition of the optimum amount of lime, is practically an impossibility, being merely a question of chance. From the point of view of keeping quality, this difficulty does not, however, matter as much as might have been expected, because our experience is that keeping quality in the case of coconut *jaggery* cannot be obtained by the use of lime only, whether used in small or large amounts.

Experiments 1, 2, 3 and 4 in the Appendix illustrate the influence of different degrees of liming on the keeping quality of coconut *jaggery*. The expressions, under-liming, normal liming and over-liming are used in a comparative sense only. By an under-limed juice we mean one which exhibits signs of slight fermentation and which is neutral or faintly acid in reaction. If the juice is bright and clear with the lime settled at the bottom of the vessel and the reaction alkaline, we describe this as normal liming. If on the other hand the lime is still in suspension and the juice has a strongly alkaline reaction and a somewhat yellow colour, it would be considered over-limed.

The four experiments quoted, which are typical of many others, indicate that keeping quality cannot be obtained merely by the use of lime. Normal liming gave the best result but even this was unsatisfactory, and, as has already been explained, it is impossible as a general rule to obtain normal liming. One may go further in fact and say that in regard to keeping quality liming is detrimental in the case of coconut *jaggery*. In experiments in which lime was not used in the collecting vessels, fermentation being prevented by the use of formalin, a very good *jaggery* was obtained which kept very much better than limed samples. This, however, is not a practical method at present and so need not be further considered.

As is well known, the coconut thrives best along the sea coast, that is to say, in districts where the sodium chloride content is high.

Doubtless, due to this association, it is found that coconut *jaggery* contains a much higher percentage of chlorine than cane *jaggery*, and it is extremely possible that this is one of the factors which determine its inferior keeping quality. Whereas samples of cane *jaggery* bought locally contained usually about 0·25 per cent. of chlorine, the coconut *jaggery* samples examined contained from 0·6 to 0·7 per cent. After liming much of this would be present in the form of calcium chloride, and the presence of 1 per cent. of such a highly hygroscopic substance would undoubtedly tend to reduce the keeping quality of the *jaggery*.

The compounds which lime forms with the gummy and other substances present in the coconut juice also seem to be of a deliquescent nature and unless removed by efficient filtration have a harmful effect.

In dealing with coconut *jaggery*, therefore, we have to face the fact that while lime is essential during the collection of the juice both on account of excise regulations to prevent fermentation and for clearing the juice, its presence is unnecessary and probably deleterious in the later stages. For reasons which have already been explained the juice as collected usually contains an excess of lime. The problem, therefore, resolves itself into the elimination of the lime before boiling the juice.

Deliming of the juice. Many ways of deliming the juice will at once suggest themselves, but most of these are at once ruled out by practical considerations. In the first place, the method employed must be exceedingly cheap, it must not involve the use of any elaborate apparatus and the technique must be simple, and the substances employed readily available to the villagers who carry on the industry.

In large topes and in particular where a licence exists for the collection of toddy it might be possible to utilize the carbonic acid from the fermenting juice to precipitate out the lime in the juice used for *jaggery* manufacture. Such a method, however, is quite impracticable for the man owning merely a few trees, and such persons form the bulk of the people engaged in the industry.

TABLE IV.

Comparative analyses of coconut jaggeries.

Nature of jaggery	Percentage of sugar	
	Sucrose	Glucose
1 Country jaggery, no alum	78·28	3·6
2. Ditto	72·32	2·3
3. Ditto	79·58	2·4
4. Ditto	75·36	4·0
5. Kasaragod farm jaggery, no alum	82·8	1·1
6. Ditto	75·2	0·8
7. Ditto	82·2	1·8
8. Kasaragod farm jaggery, alum process	83·79	1·4
9. Ditto	81·56	4·2
10. Ditto	83·15	2·5
11. Ditto	85·42	2·2

The trouble involved is, therefore, repaid by the excellent appearance of the resulting *jaggery* which is hard and white and by its superior keeping qualities.

One other point perhaps deserves mention and that is as to how far traces of alumina left in the *jaggery* might be harmful to the consumer. If the process be carried out in the manner suggested, the alumina used is completely precipitated out and there is no risk of any appreciable quantity being retained. Samples of *jaggery* prepared in this way without any special precaution have been found to contain up to 0·016 per cent. of alumina, a quantity which could not possibly cause the slightest injury to the system. Alum is extensively used already in the purification of water and edible oils, and there is no reason to suppose that its use in the manufacture of *jaggery* would lead to any harmful results.

The masses on the West Coast, as in other parts of Southern India, prefer *jaggery* to sugar. In Coimbatore the present price of cane *jaggery* is slightly higher than that of sugar. It is clear, therefore, that the manufacture of coconut *jaggery* deserves serious study, since the work we have carried out indicates that a *jaggery*

can be obtained from coconut juice fully equal to that prepared from cane.

Economics of the industry.

The problem is complicated by the fact, to which attention has previously been drawn in this paper, that the yield of juice obtained by tapping the coconut palm is extremely variable. It is consequently difficult to obtain reliable data on which to work out the economics of the industry. The use of the tree for *jaggery* manufacture means, of course, a smaller supply of nuts and a loss of revenue under that head. It is, therefore, of considerable importance to ascertain what is the exact revenue which may be obtained by the use of the trees for *jaggery* manufacture. During the past year, a large number of trees at the Experimental Coconut Station at Kasaragod have been set aside, by the courtesy of Mr. H. C. Sampson, who was in charge of the station when this work was initiated, for the study of this aspect of the question. A very large number of observations have been made as to the yield of juice which may be obtained under different conditions. It is hoped shortly to publish these results and to give a general review of the economics of the industry as possible on the West Coast. All that can be said at the moment is that when wages for tapping are excluded, that is to say when the man making the *jaggery* does his own tapping in his spare time—and this is the usual practice in Malabar—then *jaggery* manufacture yields a larger profit than the production and sale of nuts.

Appendix.

Experiment I (*normal liming*). The juice after filtration through sand was bright and sweet smelling. The reaction to litmus was distinctly alkaline both when cold and while boiling. Solidification and crystallization were extremely rapid and the *jaggery* could be removed from the moulds in five or ten minutes. Colour good. Composition, sucrose 82·8 per cent., glucose 1·10 per cent. Examined five days after manufacture, the *jaggery* was found to be nearly liquefied.

Experiment II (*under-liming*). The juice showed signs of fermentation and when filtered was still hazy in appearance. Reaction when cold, neutral or faintly acid, during boiling neutral or finally alkaline. Towards the end of boiling somewhat sticky and ropy and disinclined to crystallize. Colour good, but the *jaggery* was soft and solidified slowly. Keeping quality bad, was completely liquefied after four days. Analysis, sucrose 70·8 per cent., glucose 8·9 per cent.

Experiment III (*over-liming*). Juice heavily limed and filtered milky containing suspended lime. Reaction strongly alkaline. When heated the colour rapidly darkened, indicating destruction of sugar and caramelization. Crystallization slow and the resulting *jaggery* was soft and of inferior quality. Colour bad. Liquefied after three days' storage. Analysis, sucrose 75·2 per cent., glucose 0·80 per cent.

Experiment IV (*normal liming*). Juice clear and bright with alkaline reaction. Boiling was carried out with great care to prevent overheating. Crystallization good and resulting *jaggery* was hard and had an excellent appearance. The keeping quality was in no way improved, however, as liquefaction commenced on the third day. Analysis, sucrose 83·5 per cent., glucose 1·8 per cent.

Experiment V (*no lime*). No lime was added to the collection pots, fermentation being prevented by the use of a small quantity of 10 per cent. formalin. After collection the juice was neutralized by the addition of a little 1 per cent. potash and then boiled in the usual way. The resulting *jaggery* was of excellent quality, being hard and possessing a good colour. Kept well for ten days. Analysis, sucrose 87·04 per cent., glucose 1·88 per cent.

Experiment VI (*formalin followed by lime*). Experiment in the early stages similar to Experiment V. Towards the end of boiling a small quantity of powdered lime was dusted in, this being sometimes done in the case of cane *jaggery*. Crystallization good and a hard *jaggery* was obtained. The colour was distinctly inferior to that obtained in Experiment V. Kept well for nine days. Analysis, sucrose 82·60 per cent., glucose 1·58 per cent.

Experiment VII (*lime and alum*). The limed juice was treated with a small quantity of alum. The resulting precipitate rapidly settled and the clear juice was decanted off and boiled down in the usual way. Crystallization rapid, colour almost white and the *jaggery* was hard and kept well, being still intact after ten days' storage. Analysis, sucrose 81·56 per cent., glucose 4·22 per cent.

Experiment VIII (*lime and alum*). Juice collected in the evening was not boiled immediately but kept until the following morning. Being heavily limed it remained perfectly sweet and free from fermentation though the colour became somewhat darker. Such a juice if boiled directly would have given an exceedingly dark *jaggery* owing to the excess of lime. The juice was delimed with alum as in Experiment VII, and concentrated as usual. The resulting *jaggery* was entirely satisfactory, hard, white and kept well. Analysis, sucrose 83·79 per cent., glucose 1·4 per cent.

Experiment IX. Juice was collected during the night without liming the pots, the latter containing about 2 grm. of ashes. When examined in the morning fermentation had began and the reaction was acid. The juice was made slightly alkaline with lime and the excess of lime removed by alum. The resulting *jaggery* was a hard milk-white product. Ordinarily if fermented juice is boiled down, the *jaggery* obtained is soft and not easily crystallizable. Analysis, sucrose 78·28 per cent., glucose 5·6 per cent.

Experiment X. The juice was over-limed and then delimed as described above with alum. The resulting precipitate, however, was not removed, being boiled down with the juice. The *jaggery* obtained has a good colour but was extremely hygroscopic and began to liquefy in a few hours. Similar experiments have confirmed this result, indicating the necessity of removing the precipitated lime.

Experiment XI. Juice collected in the evening was not boiled directly but stored till morning when it was mixed with the morning juice. Though not heavily limed, fermentation had not begun and the juice was quite sweet. Delimed with alum. *Jaggery* hard, white and kept well.

From Experiments VIII and IX it will be seen that it is possible by the use of alum in the later stages to add such amounts of lime to the collection pots that the juice can be kept until a convenient time before boiling without fear of fermentation commencing and without harm to the *jaggery* subsequently produced.

STUDIES IN METHODS TO PREVENT NITROGEN LOSSES FROM DUNG AND URINE DURING STORAGE.*

BY

N. V. JOSHI, M.Sc., B.A., L.Ag.,

First Assistant to the Imperial Agricultural Bacteriologist.

As the chief constituents of farmyard manure, the dung and urine of cattle are the principal sources of manure to the agriculturists all over the world : and they are practically the only source of manure to the small cultivator in India : and hence it is of great importance to store them in such a way as to preserve the maximum amount of fertilizing value available in them. Owing to fermentation and drainage, however, very serious losses, especially of nitrogen, occur during their storage. The losses due to drainage can possibly be avoided by suitably constructed pits or tanks,[1] but the losses occurring during fermentation require in the first place a study of the optimum conditions that must be maintained in order to prevent any losses that might occur during storage.

In previous work[2] on the decomposition of cowdung and urine in the soil the present writer made some preliminary observations on the losses of nitrogen from dung and urine. It was found that there was practically no loss of nitrogen from urine when stored under anaerobic conditions, while under aerobic conditions an enormous loss of nitrogen occurred. Losses in the nitrogen contained in cowdung stored under aerobic conditions were not properly worked out at the time, but under anaerobic conditions there was only a slight loss of nitrogen when the cowdung was

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[1] *Jour. Bd. of Agri.*, XXVI, pp. 431–436.

[2] Joshi, N. V. *Jour. Agri. India*, XV, July 1920.

separately stored in that way. Sheep manure which was a mixture of dung and urine, however, lost a good deal of nitrogen.

Further experiments on storage of dung and urine under different conditions have since been carried out by the writer and these form the subject matter of the present paper.

It may be pointed out in the beginning that agriculturists in certain parts of India practically throw away all the urine as they have not yet realized its value as manure. On account of this fact and also on account of the wide variations in the proportions of dung and urine that go to make up the farmyard manure in different parts of the country, it was considered necessary to study the losses of nitrogen from dung and urine stored separately instead of in mixtures. It was also held that this procedure would enable us to find out which of these substances by itself is responsible for the serious losses that occur in the making of farmyard manure. Although a study of the losses of nitrogen from mixtures of cattle dung and urine in different proportions was not undertaken, determinations of losses in nitrogen from dung and urine mixed in one definite proportion were, however, made in the course of the present investigation, in connection with the materials used as absorbents for urine.

Experimental.

Storage of dung.

Fresh dung was collected and after thoroughly mixing the same a portion was taken for determination of nitrogen in the fresh state and the remainder filled in glass jars. From two to three kilos of the material was required to fill the jars. Glass jars were used in these experiments in order to avoid all losses through drainage. The jars that were to be kept under anaerobic conditions were filled practically up to the top and covered with ground glasses and made air-tight by vaseline and rubber lute. Those that were to be kept under aerobic conditions were similarly filled up but were kept covered with a thin piece of cloth only. Occasionally the dung in the aerobic jars was stirred with a glass rod so as to prevent packing. The amounts of nitrogen, moisture, and loss in weight of

each jar were determined at intervals from one aerobic and one anaerobic jar each time. Sometimes determinations were made from two jars. Duplicate or triplicate determinations of nitrogen were always made in each case. The following table gives the average of the percentage losses calculated on the original amount of nitrogen contained in the dung.

TABLE I.

Per cent. losses and gains in nitrogen calculated on the total amount of nitrogen contained in the dung during storage.

+gain in nitrogen.

—loss in nitrogen.

1920-21.

Conditions of storage	1 month	2 months	3 months	5 months	7 months
Aerobic	− 6·5	− 9·6	− 9·4	− 6·2	− 16·2
Anaerobic	− 5·9	+ 3·7	+ 3·0	− 3·1	− 7·0

1921-22.

Conditions of storage	6 weeks	8 weeks
Aerobic	− 3·0	− 9·0
Anaerobic	+ 7·0	+ 1·5

From these results it is clear that cowdung when stored by itself is subject to only slight losses of nitrogen due to fermentation during storage whether under aerobic or anaerobic conditions. Under anaerobic conditions, at certain periods, a gain in nitrogen is also noticeable. It is very likely that larger gains in nitrogen could be secured by suitably varying the conditions of storage, but in order to find out what these exact conditions are, a detailed investigation is necessary.

Storage of urine.

We may now turn our attention to the investigation on the storage of urine. For this purpose fresh urine was collected and after

thoroughly mixing the whole by shaking, samples were taken out for determining nitrogen. The remaining material was filled in wide-mouthed glass bottles of 500 c.c. capacity, right up to one inch below the top.

Two of these bottles were kept open and two more were kept stoppered to prevent any access of air. These two sets represent the aerobic and anaerobic conditions of storage. As several preliminary experiments had already shown that large amounts of nitrogen are lost under aerobic conditions, and that practically no loss of nitrogen from urine occurs under anaerobic conditions, it was proposed to introduce a variation in the method of obtaining anaerobic conditions in the experiment. Now covering the surface of a liquid medium with some oil is often used to produce anaerobic conditions in bacteriological technique. It was, therefore, proposed to try and compare this method of securing anaerobic conditions along with the use of glass stopper. In two bottles, therefore, the surface of urine was covered with a kerosene oil layer about one-eighth to one-fourth of an inch thick and in two others coconut oil was used for the same purpose. Mustard oil also was tried on one occasion. Nitrogen was determined from each bottle in duplicate at intervals. The following table gives the average of the losses in percentage of the original nitrogen contained in the urine.

TABLE II.

Per cent. losses in nitrogen calculated on the total amount of nitrogen contained in the urine during storage.

1920-21.

Conditions of storage	1 month	2 months	3 months	5 months	7 months
Aerobic (open bottle)	42·2	77·3	0·0	94·4	99·5
Anaerobic (glass stopper) ..	1·9	2·0	2·6	4·6	7·0
Anaerobic (surface covered with kerosene oil)	3·9	4·8	6·0	10·0*	16·0*
Anaerobic (surface covered with coconut oil)	2·1	2·3	14·8*	18·0*	23·5*

* Oil layer had become much thinner during sampling and could not properly cover the surface of the urine and some evaporation of moisture took place.

1921-22.

Conditions of storage	6 weeks	8 weeks
Aerobic (open bottle)	36·9	52·7
Anaerobic (closed with glass stoppers)	0·3	3·4
Anaerobic (surface covered with a layer of kerosene oil)	0·4	4·2
Anaerobic (surface covered with a layer of mustard oil)	0·1	1·5

It will be seen from this table that under anaerobic conditions, *i.e.*, where the glass stopper or layers of oil were used to cover the surface of the urine, the losses of nitrogen from urine are practically nil for a long time. It may be added here that under these conditions the surface of the liquid being covered there is very little loss of moisture from surface evaporation with which process the losses in nitrogen are assumed to be correlated by some investigators.

In any case covering the surface of the urine is a simple device by which cattle urine, when it is not required for immediate use, can conveniently be stored in some suitably constructed pits, especially as this arrangement would secure the full benefit of all the nitrogen contained in the liquid manure. This method of conserving the nitrogen in urine has the merit of simplicity and is expected to prove economical in practice and deserves trial on a larger scale by the agriculturists.

Since much of the loss of nitrogen in the case of urine stored under aerobic conditions is attributed to volatilisation of ammonia resulting from the decomposition of urea and other nitrogenous compounds contained in the urine, several substances like sulphuric acid, superphosphate and sodium bisulphate, which neutralize the ammonia, are often recommended for conserving the nitrogen. The use of formalin which forms a non-volatile compound with the liquid manure has also been suggested for avoiding losses of nitrogen from urine. Among other substances gypsum, calcium chloride, kainit and other potassium salts are said to be useful in conserving the nitrogen of urine by preventing decomposition of urea. Most of these materials were tried on a small scale but many have proved

inefficient in the proportions so far tried. Formalin, sulphuric acid, and superphosphate, however, have given encouraging results but the cost of these materials in the proportions used in our experiment is expected to prove prohibitive and hence further details of these experiments are not given here.

Among other methods of conserving urine and liquid manure the use of absorbents like peat, litter, soil, etc., is often suggested. It was proposed to try some of these in the case of urine ; soil and finely chopped straw were selected for the purpose. A measured amount of urine was absorbed by each of these substances separately. These mixtures were then kept in open jars covered with thin cloth. The losses of nitrogen occurring under these conditions are given in the following table.

TABLE III.

Per cent. loss in nitrogen of the total nitrogen in urine during storage by absorbents.

1921-22.

Absorbent used	6 weeks	8 weeks
Soil	75·9	80·8
Chopped straw	62·1	66·2

Both these methods of absorbing urine lead to great losses and perhaps are not worth the trouble involved. It may be noted, however, that urine added to the soil in proper proportions (3 : 100) does not lead to much loss of nitrogen as is evident from several nitrification experiments carried out in this laboratory some of which have been previously reported.[1]

Fresh cattle dung was next tried as an absorbent. Fresh dung and urine were mixed in the proportion of 10 : 1 and the mixture was stored in jars, about two kilos in each jar, both under aerobic and anaerobic conditions. The losses of nitrogen that occurred under these conditions are given in the accompanying table.

[1] Joshi, N. V. *Jour. Agri. India*, XV, July 1920.

TABLE IV.

Per cent. loss in nitrogen of the total nitrogen in mixtures of dung and urine.

1921-22.

Conditions of storage	6 weeks	8 weeks
Aerobic	29·5	30·5
Anaerobic	4·0	7·6

Although the loss of nitrogen in the case of cattle dung as an absorbent of urine is small as compared to the other absorbents like soil and straw, the chief thing to be noticed from the above results is the fact that greater losses of nitrogen have occurred in the case of the mixture of dung and urine than from either of these alone, under both conditions of storage, aerobic as well as anaerobic. It will also be found after further calculation that the total amount of nitrogen that would have been lost from the same quantities of materials had they been stored separately is much smaller than the amount actually lost from the mixture of the materials. Thus in six weeks had the same quantities of dung and urine, as were used in the mixture, been stored separately under aerobic conditions, they would have together lost only 12·8 per cent. of their total nitrogen; but in the mixture they have lost 29·5 per cent. Again in eight weeks the percentage that would have been lost if separate storage had been practised would be 19·6 but the actual loss in the mixture is 30·5 per cent. of the total nitrogen. Somewhat similar results, though on a smaller scale, are met with if the figures for anaerobic conditions are taken into consideration.

This greater loss of nitrogen is probably due to the action of cellulose-decomposing organisms which bring about the destruction of easily available nitrogenous compounds like urea. It is not, however, necessary for us at present to find out exactly how the loss takes place. It is sufficient for our purpose to know that greater losses of nitrogen occur if cattle dung and urine are mixed and stored together. It is advisable, therefore, to store these materials

in separate pits if a saving of the nitrogen contained in them is desired.

Summary.

The results of the investigation may now be summed up as follows :—

1. The losses of nitrogen from cattle dung when stored separately are small under both aerobic or anaerobic conditions of storage.
2. In the case of urine great amounts of nitrogen are lost under aerobic conditions, while under anaerobic conditions the losses are negligible.
3. Covering the surface of the urine with a layer of some kind of oil such as kerosene, mustard or coconut brings about the necessary anaerobic conditions and this method has proved effective in preventing losses of nitrogen from the urine.
4. Among several substances tried to prevent losses of nitrogen from urine occurring under aerobic conditions of storage, sulphuric acid, superphosphate and formalin have proved effective but their cost is expected to be prohibitive in practice.
5. Very great losses of nitrogen have been observed when straw and soil were used as absorbents for urine. These absorbents would therefore not prove of value in conserving the nitrogen of the urine.
6. Since greater losses of nitrogen occur in the mixture of cattle dung and urine, it is advisable to store cattle dung and urine in separate pits instead of following the prevalent practice of mixing them in storage.

and weeds thoroughly buried with their roots exposed. In soil of this nature and in this moist condition nothing apparently can stop the tractor, which went readily through even formidable clumps of *patawa* with scarcely any hesitation. Under these conditions the tractor will take three ten-inch furrows with ease to the depth required.

The plough was next tried on a plot of very hard yellowish clay quite impervious to the ordinary country plough, and made a furrow from 4 to 5 inches deep. The land was covered with *kans* and the object of the trial was merely to test the power and efficiency of the machine, which it satisfactorily demonstrated. After the initial experiments, work was continued at Rehawa by a soldier driver from the Lucknow Technical School who had been trained by the Agricultural Department. The idea was to prepare for cultivation as much of the land as possible before the first monsoon showers. For this purpose one ploughing proved insufficient as the ordinary country plough cannot easily break up the turned over soil after it has thoroughly dried and hardened, and to do this earlier would be fatal as it is essential that the uprooted reeds should be completely scorched by the sun to prevent revival. It is necessary, therefore, to time the first ploughing so as to allow sufficient opportunity for the second or cross-ploughing to be completed before the break of the rains.

Cross-ploughing with the same implement as was used to break the land is an expensive operation, so a tandem disc harrow was tried but proved ineffective, as it failed to reach the bottom of the furrows even with extra weights applied. It is necessary to do this, as otherwise a great portion of the weeds which have been turned over survive and will recrudesce.

After a certain amount of drying the soil was in good condition for cross-cultivation, and probably a heavy tractor grubber would prove effective in removing grass roots and leaving the land in fit condition for the *desi* plough but as no suitable grubber was obtainable in time cross-ploughing was resorted to. This operation was somewhat easier than the first ploughing, and correspondingly cheaper as more work was done for the same power expended, and

it is certainly very efficient. The sods are thoroughly turned and broken up and the surviving weeds again exposed to the action of the sun. And it may well be that this is the very best method when operating on land covered with *kans* and *gandar*. If cross-ploughing is timed to be completed at least 15 days before the rains break, practically all the more noxious reeds are exterminated and the land can be kept clear of them with very little labour.

The land ploughed was offered to tenants on rent or profit-sharing terms. The majority chose the latter by which the estate takes one-third of the produce as its share of once-ploughed land or one-half the produce of cross-ploughed land, the tenant doing all operations after reclamation and providing seed and taking the rest of the produce. In most fields rice was sown at the beginning of the monsoon.

The plots reclaimed were inspected by one of us in August. Those ploughed once only were more or less completely overrun with weeds though this in a great measure was due to no attempt having been made to weed them at all. The cross-ploughed plots on the other hand showed very little *kans* and *gandar* even in fields which had not been weeded and were remarkably clean where some attention had been given to that operation. Apparently one good weeding is sufficient to keep a cross-ploughed field clean. Rice had been sown in both once-ploughed and cross-ploughed plots. In the former the crop was backward in weeded fields and practically swamped * where no weeding had been done. The unweeded cross-ploughed plots showed more forward crops and the weeded fields were quite up to the normal of fields which have been long under cultivation.

The whole area broken with the tractor was 91·93 acres out of which 19·79 acres was cross-ploughed. The acreage is undoubtedly small, the reasons being that first the plough broke down and some time was lost in replacing the broken part and then the tractor itself broke down at the busiest season. The daily amount of work done too was below expectation, due partly to the inexperience of

* Abnormal floods occurred this year.

the driver. Some energy was wasted in the beginning by working on scattered plots and plots which afforded comparatively short runs for the tractor. Long narrow fields provide the best conditions for work—the longer the better. Nevertheless so far as it goes, the experiment promises to be a success and to yield a satisfactory return on the outlay. The consumption of kerosene amounted to 159½ tins costing Rs. 747-10-6, petrol (for starting) 8½ tins (about Rs. 34) and lubricating oil, grease, etc., costing Rs. 202 were used. The pay of the driver and cleaner for the whole period of the experiment (including the time the tractor was not working on account of the damaged plough) amounted to Rs. 430, a very high figure for the area ploughed even after allowing for moving about and experiments on small plots. The estimated value of the estate's share of the produce is Rs. 1,676, and thus there should be a profit of Rs. 263 this year. The whole of the rent in future years will be clear profit as, but for this expenditure, there was little hope of the land being taken under cultivation.

The aggregate figures are disappointing, the work done per day is much below the capacity of the tractor (as we ascertained by personal trial again in February), and the cost of petrol, kerosene and lubricating oil per acre at least 50 per cent. too high.

The following analysis of the daily records is of interest :—

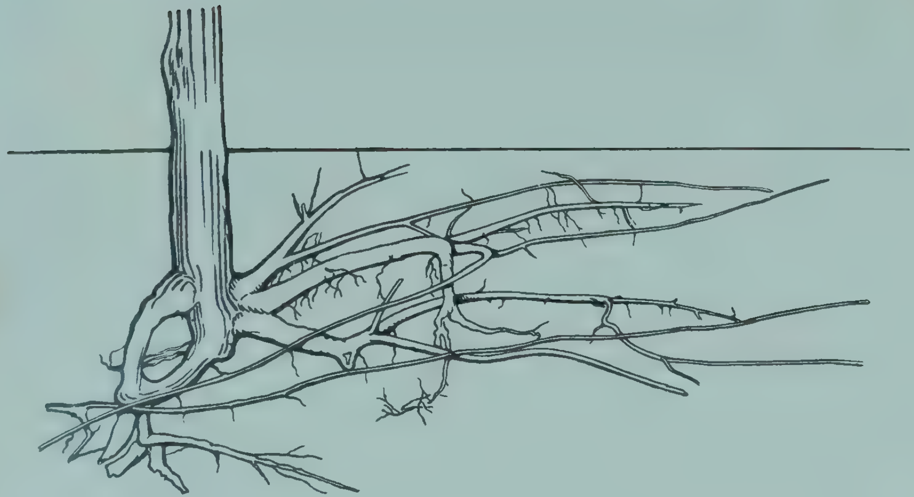
Month	Days worked	Best day's work		Worst day's work		Average day's work	
		Acres	Hours	Acres	Hours	Acres	Hours
PLOUGHING							
November ..	2	1·4	8	..	..	1·35	8
December ..	21	1·2	7	0·35	5	0·90	7
January ..	20	1·6	6	0·62	6	0·90	7
February ..	19	1·5	7	0·67	7	1·10	7
March ..	14	1·6	7	0·85	7	1·05	7
CROSS-PLOUGHING							
March ..	2	1·71	7	1·52	7	1·61	7
May ..	10	{ 2·5 1·42	7 } 3 }	1·32	7	1·80	7

Kerosene consumption kept practically constant at 7 gallons per day, averaging 1·04 gallons per hour. From this it is obvious that the tractor was not developing much over half power. We twice satisfied ourselves by personal trial that it could have been driven considerably faster and that under most conditions a three-furrow plough should have been used.

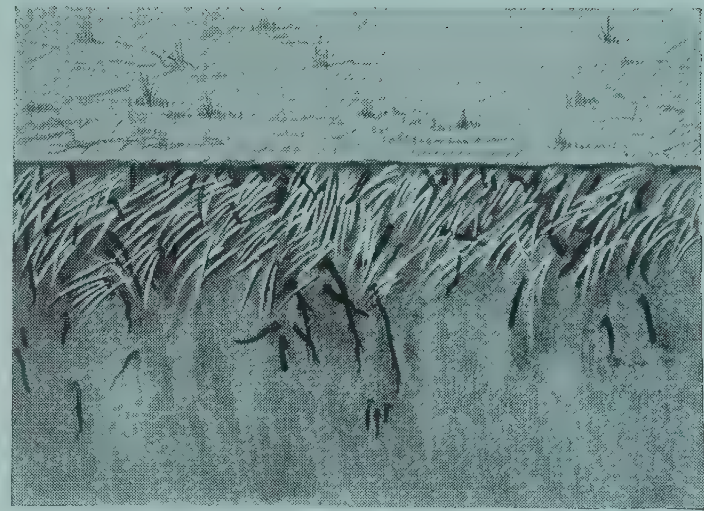
Nevertheless, despite unfavourable circumstances the rent recovered in the first year has more than covered the working expenses of reclamation.

Delays due to first implement and then tractor breakages have been referred to above. These were all due to lack of skill on the part of the driver but must be expected. Too much stress cannot be laid on the absolute necessity of a good spare part service if any agricultural tractor is to succeed in India.

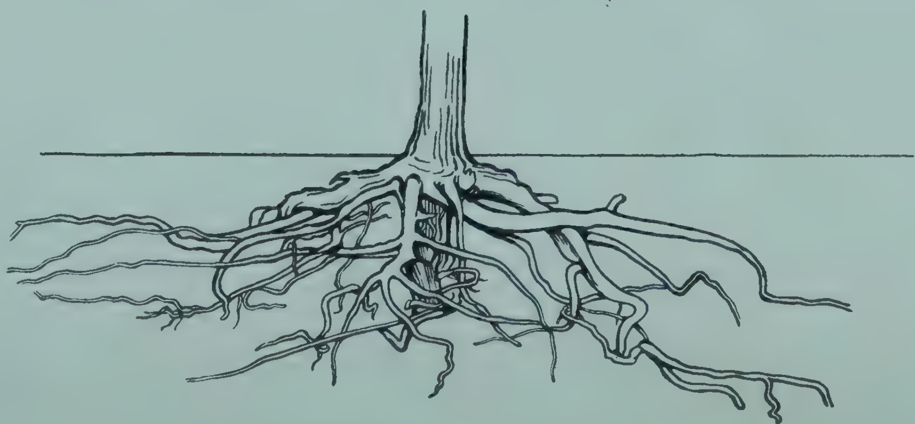
Certain Tree roots



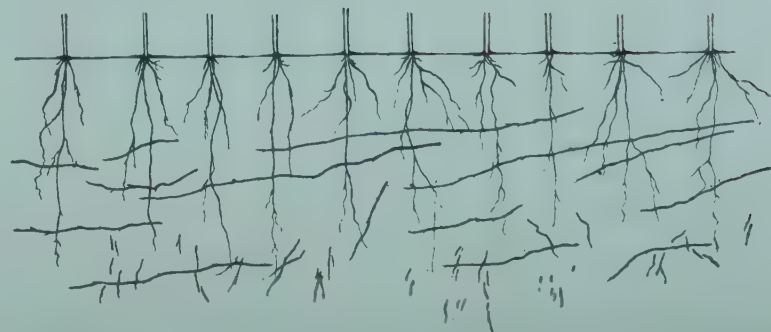
Tamarindus indica
(1)



Bambusa arundinacea Thespesia populnea
(3)



Melia Azadirachta



Roots of Pithecolobium saman crossing the path of Cholam roots

SUGARCANE ROOT SYSTEMS: STUDIES IN DEVELOPMENT AND ANATOMY.*

BY

RAO SAHIB T. S. VENKATRAMAN, B.A.,
Government Sugarcane Expert;

AND

R. THOMAS,
Acting Botany Assistant, Cane-breeding Station, Coimbatore.

INTRODUCTION.

OWING to their underground nature and comparative inaccessibility resulting therefrom, roots of plants have received less attention than the above-ground portions. A considerable amount of work hails from America[1] where attention appears to have been devoted to this subject from as early as the close of last century. In India, Dr. C. A. Barber, C.I.E., the then Government Botanist at Coimbatore, started a series of such studies in 1910-11. The results were, however, never published but got assimilated into the teaching at the Coimbatore Agricultural College. In recent years, this subject has been receiving considerable attention from the Howards at Pusa.[2]

NEED FOR A SYSTEMATIC STUDY OF ROOTS.

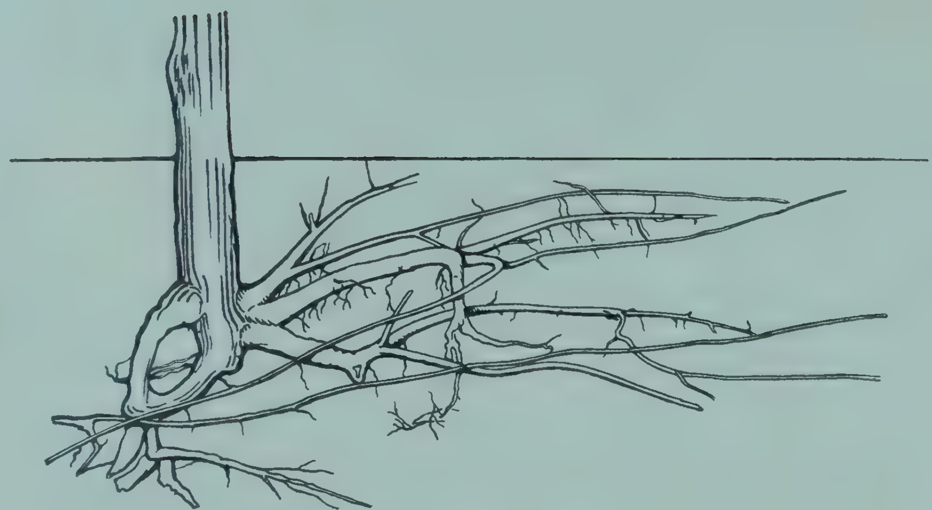
The comparative greater uniformity obtaining in soil, as contrasted with atmospheric conditions, imposes a greater

* Paper read at the Ninth Indian Science Congress, Madras, 1922.

[1] An up-to-date bibliography is to be found at the end of Publication No. 292 from the Carnegie Institution of Washington.

[2] *Agri. Jour. India*, Special Indian Science Congress Nos. 1917, 1918 and 1919.

Certain Tree roots

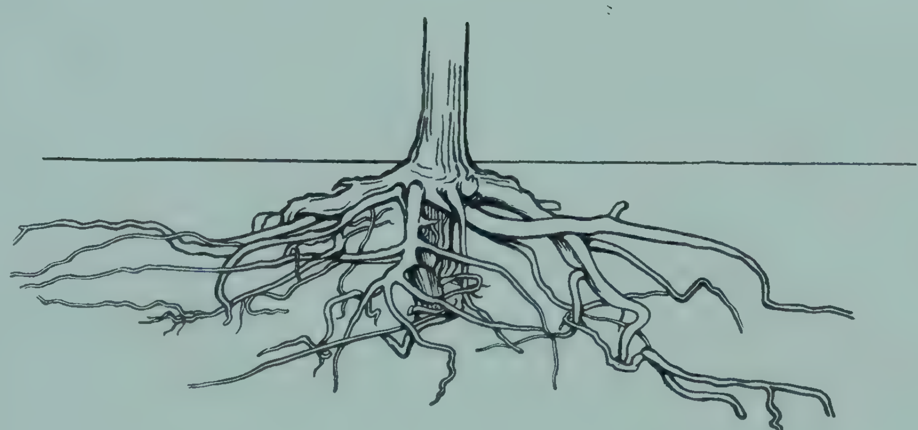


Tamarindus indica

(1)

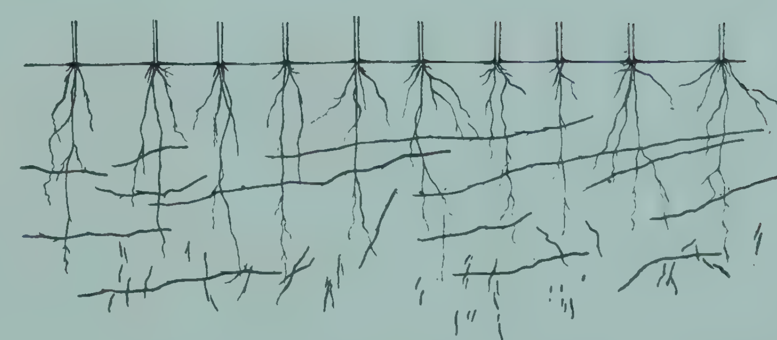
Bambusa arundinacea Thespesia populnea

(3)



Melia Azadirachta

(2)



Roots of Pithecolobium saman crossing the path of Cholam roots

(4)

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[2] *Agri. Jour. India,* Special Indian Science Congress Nos. 1917, 1918 and 1919.

uniformity in modes of growth and structure of sub-soil as compared with sub-aerial organs of plants. But even so the adaptations are well worth a careful study. Man brings his influence to bear on the plants he cultivates or the trees he grows chiefly through the soil and hence through the roots. A systematic study of the latter is, therefore, bound to be of profit. Besides its obvious utility in questions relating to crop rotation, a study of the root systems of cultivated crops promises to yield valuable indications on such useful characters as tillering and drought resistance.

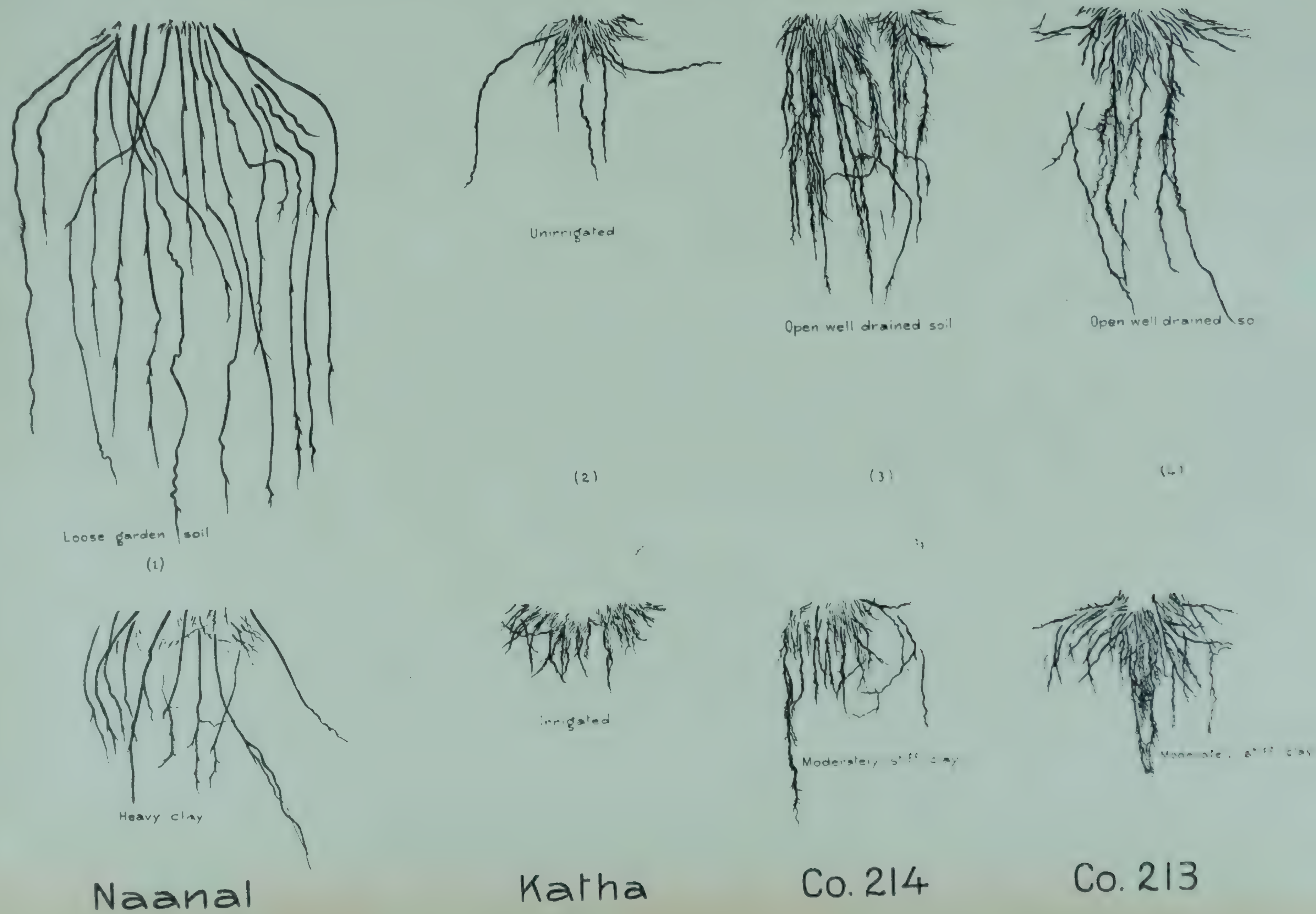
Certain tree roots.

As the result apparently of long observation, the man in the field has come to entertain certain ideas regarding the effect of particular trees on the adjoining crops. An examination of the root systems would appear to justify the explanation of some of these effects, largely on the basis of competition between the tree roots and those of the crop.

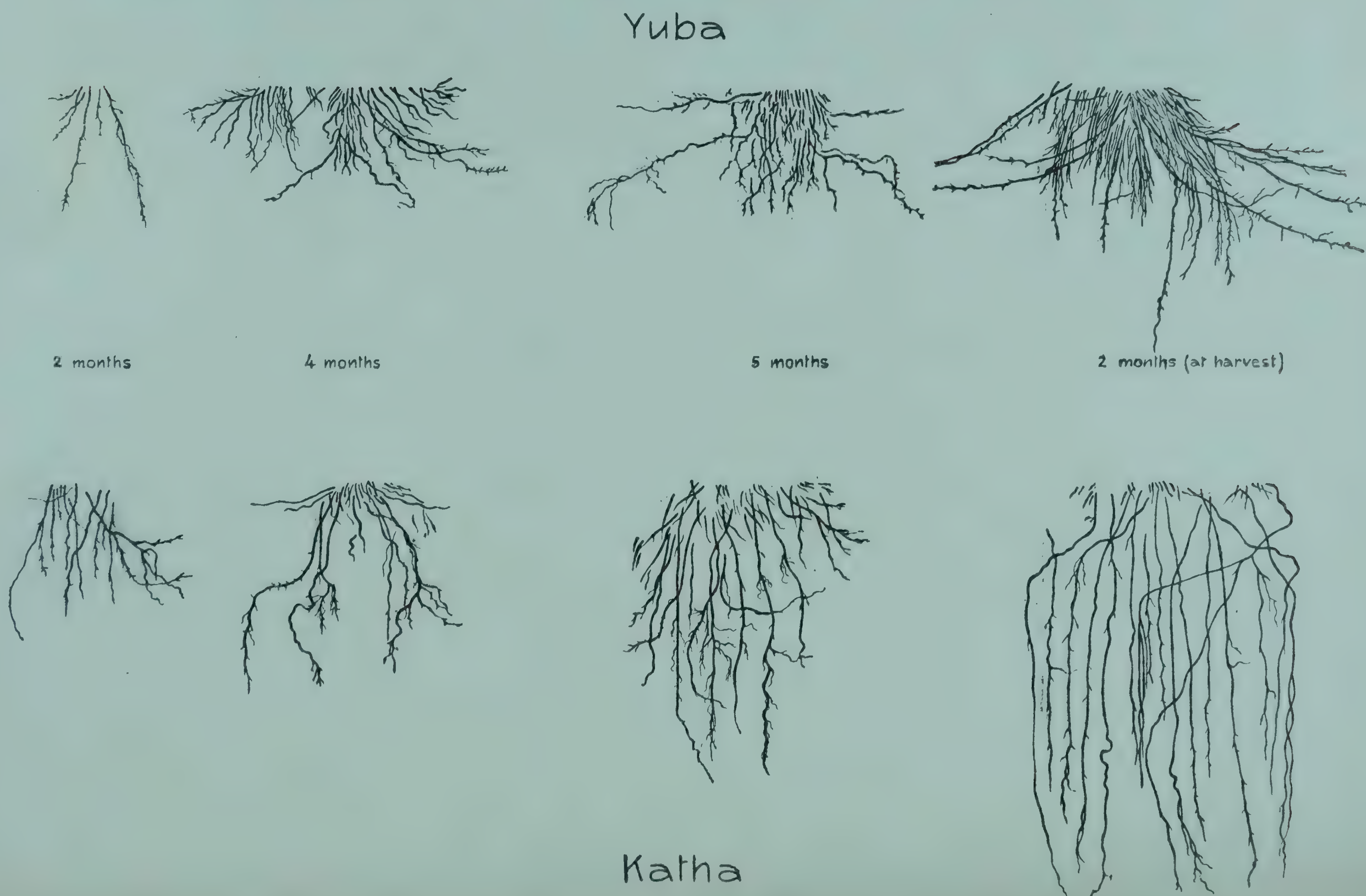
The tamarind (*Tamarindus indica*), for instance, has an ill repute for its smothering effect on a crop of *cholam* (*Sorghum*) or cotton growing near it. The roots of this tree—even those arising from the lower portions of the tap root—show a marked tendency to come to the surface. The resulting competition for plant food and soil moisture to the disadvantage of the young *cholam* crop is obvious (Plate XVII, fig. 1).* The writers have frequently been able to overcome this by opening a deep trench next to the tree a good time before the sowing of the crop. The *neem* (*Melia Azadirachta*), on the other hand, which is known to be much more friendly to the crops in the vicinity, possesses a deeper root system, thus eliminating the serious competition during at least the earlier stages of the growth of the crop. Healthy crops of *cholam* or *ragi* (*Eleusine coracana*) right up to the trunks of *neem* trees are often to be found.

* Figures 1 and 2 of Plate XVII belong to the studies made by Dr. C. A. Barber in 1910-11 and referred to in the introduction.

Effect of environment on root development in Sugarcanes.



Varietal differences in sugarcane root-systems (mode of development)



The bamboo* (*Bambusa arundinacea*), which has a very bad record in this respect, shows a close felt of roots very near the surface, thus effectively choking all other vegetation in the immediate vicinity. It is interesting to contrast with it the root system of the Portia (*Thespesia populnea*) tree which is known to be more tolerant. Plate XVII, fig. 3 shows a cross section of soil equidistant from a bamboo clump and a Portia tree. It is obvious that the deeper and sparser nature of the roots of the latter would offer a less serious competition than the close felt of surface roots of the bamboo.*

Tree enthusiasts, especially when recommending particular species for planting in a garden or an agricultural farm, would be well advised to bear in mind the root system of the species. The rain tree (*Pithecolobium Saman*), for instance, which has a certain amount of popularity on account of its quick growth, possesses an extensive surface root system adversely affecting crops in immediate vicinity. Plate XVII, fig. 4 shows the obvious competition between the advanced roots of this tree and those of a young *cholam* crop in the neighbourhood which called attention by an appearance of drought effect in spite of the normal irrigations given. So extensive is the root system of this tree, that recently a particularly robust specimen from an avenue of these was found on examination to derive the bulk of its nourishment from a well kept garden situate on the other side of the road away from the tree.

Study of sugarcane roots.

Sugarcane varieties, especially those grown in India, cover a very wide range in respect of morphological and physiological characters and conditions of growth. They include the thin, primitive, hardy, reed-like canes of the Punjab and Western United Provinces, the medium canes of Bengal, Bihar and Orissa, the thick, rich, juicy tropical canes of Madras and Bombay, varieties maturing at varying periods from eight to fourteen months, forms growing

* Dr. J. N. Sen has noticed a concentration of injurious salts near the roots of the tamarind and the bamboo (*Agri. Jour. India*, XII, July 1917).

practically under marshy conditions and others extremely susceptible to water stagnation. The present studies are an attempt at discovering adaptations in modes of growth or structure of the roots in response to these varying conditions.

(*a*) *Effect of environment on root development in sugarcanes.*

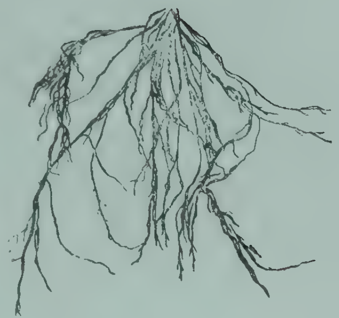
In a comparative study, like the one herein contemplated, it is necessary to carefully assay the effect of all possible factors other than the one under study or carefully eliminate them. In root development, soil conditions, chiefly texture and moisture contents, exert a marked influence both on the plan and quantity of roots developed. Plate XVIII illustrates the effect of different kinds of soil on root development of the same cane variety. Figs. 1, 3 and 4 (*viz.*, the roots of Naanal, Co 214 and Co 213) demonstrate the inhibitory effect of a stiff as compared with a free open soil. The curtailment of the root system, when moisture is made available within a comparatively short distance by irrigation, is illustrated by Katha roots in fig. 2. The same variety when grown without irrigation develops a larger and deeper root system, obviously to secure an adequate supply of moisture by tapping larger cubic contents of relatively drier soil. It follows, therefore, that in a varietal study of root development the soil and moisture conditions should be kept absolutely uniform.

(*b*) *Rapidity of root development after planting.*

The time taken by the sets to root after planting varies widely in different varieties. Early rooting is a desirable character in cane cultivation, as it means a quicker establishment of the plant with a consequent curtailment of the period of anxiety for the grower during the early stages of growth. The different groups of indigenous canes show characteristic differences, the Saretha and Pansahi * groups showing a quicker root development than those of the Sunnabile and Mungo groups, the last being easily the tardiest. The

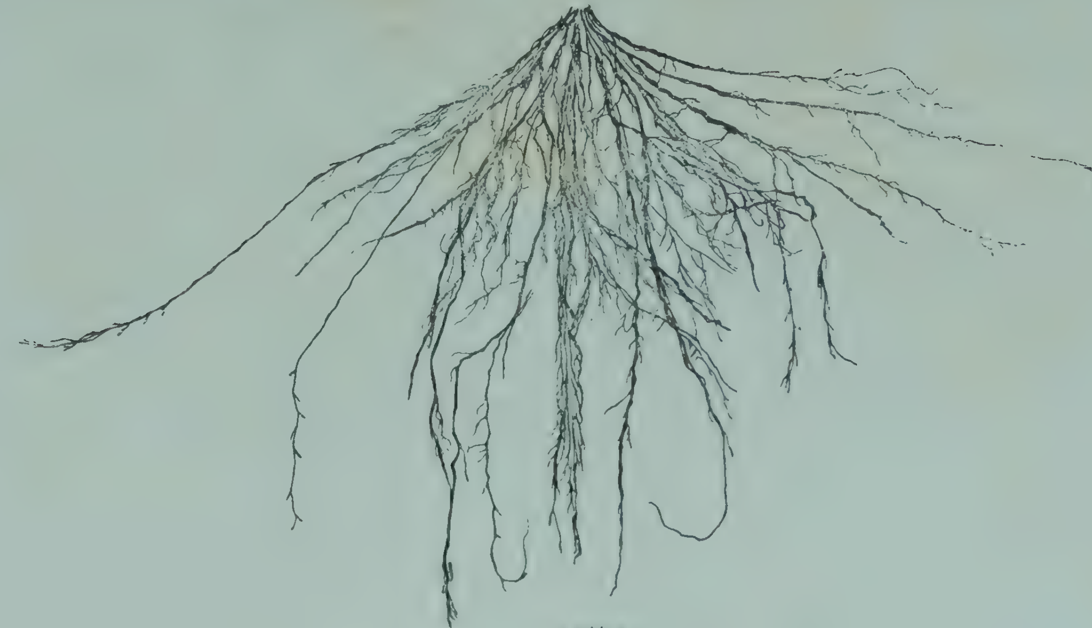
* The classification here adopted is the one by Dr. C. A. Barber (*Agri. Jour. India*, XI, Oct. 1916).

Varietal differences in Sugarcane root-systems.



Vellai
(1)

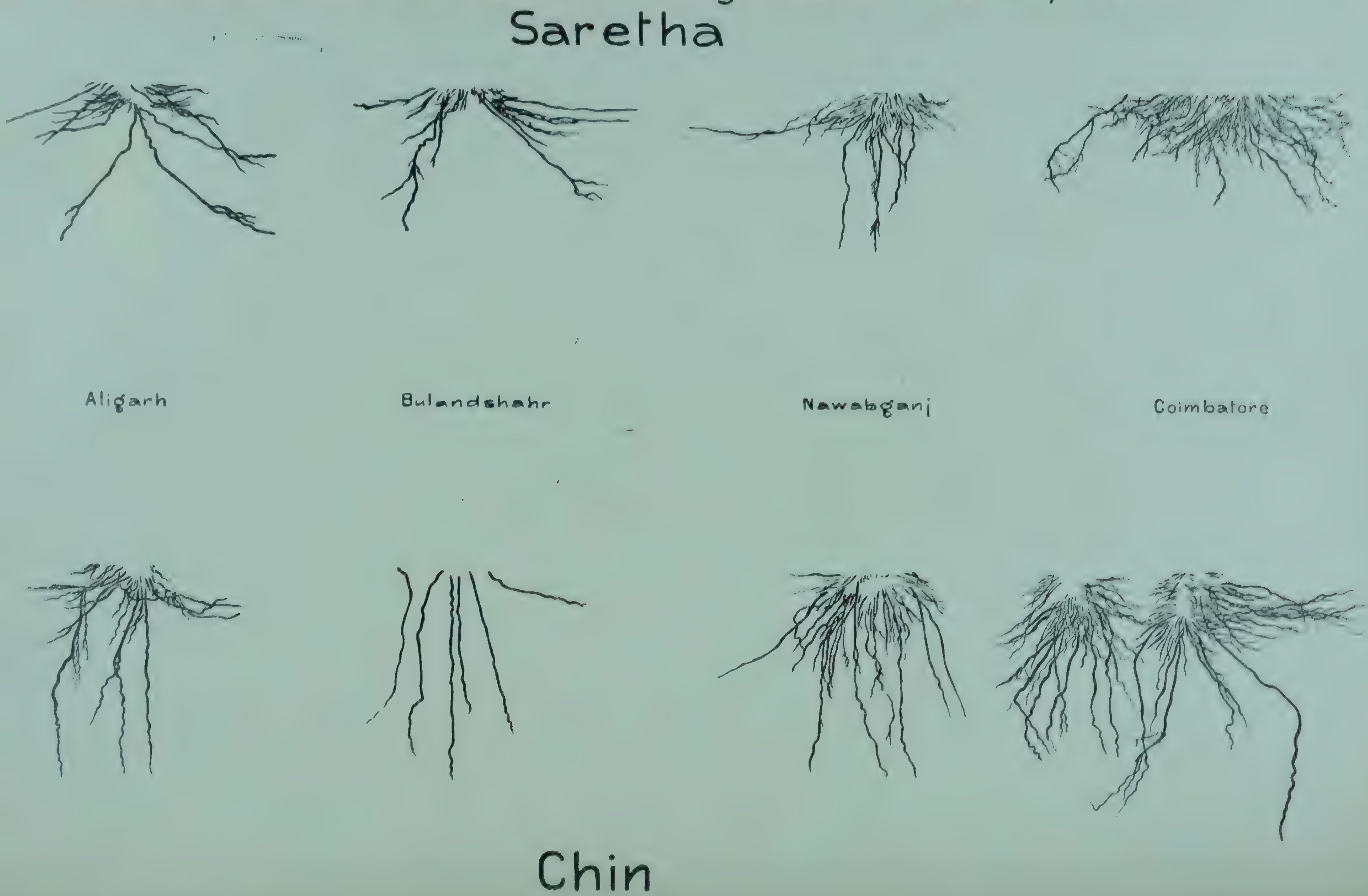
Naanal
(2)



Katha
(3)

Sanachi
(4)

Varietal differences in Sugarcane root-systems



development of the above-ground shoot is closely correlated with that of the root. In certain cases, such as the Naanal or some of the members of the Mungo group, the root development starts only after the shoots have come out of the ground and grown a little.

In canes, tillering generally commences only after the shoots begin to give out roots, whatever may be the development of the set roots.

(c) *Plan or habit of the roots.*

A varietal difference of considerable importance is found in the mode or plan of development of the roots. This is correlated with at least one important agricultural character, drought resistance, and it appears possible that it may be correlated with frost resistance as well.

(1) *Methods of study.* In the earlier stages of the study the examination of the root systems was based on careful dissections in the field conducted as below. A deep pit is dug vertically down the edge of the plant and of sufficient size to accommodate a couple of coolies. All the roots of the plant, to a specified thickness of soil and extending to the right and left of the plant as far as they are traceable, are carefully dissected by trained coolies who, as the dissection proceeds, place the roots as much as possible in their natural positions. The system is then photographed with a scale inserted at one end, whitewashing the roots to secure a contrast against the dark or brown background of the soil.

A second method, a copy from America and used to a certain extent in these investigations, is to dig a deep pit on two opposite sides of the plant, place vertical pieces of two-inch wire mesh on the plant side of the pits, insert thin iron rods through the breadth of interposed soil and wash out the soil with water. The iron rods keep the roots more or less in position and the system can be conveniently studied and photographed.

A third method, which has been recently evolved by the senior author, consists of previously laying the plot with horizontal layers of wire netting at suitable heights, refilling the excavations with the soil taken out, taking care to place the layers in the same positions

in which they were taken out, and growing the plants, whose root systems it is intended to study, on these previously prepared plots. For examining the roots, all that is needed is to turn the water on to the plot and wash out the soil, when the root system alone will be left, each strand more or less in the original position being caught in the meshes of the interposed wire netting.

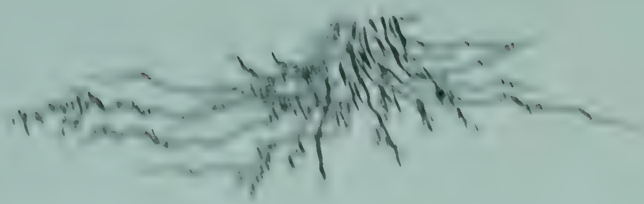
The first is laborious, expensive and needs considerable care. The second is difficult of application in localities where the soil is sticky and does not wash out, but, like the third, it is to a great extent fool-proof. It has the advantage over the third method in that it can be used for studying the system of any plant anywhere. The third has been found to be cheap and fool-proof but is applicable only to plants specially grown for the purpose. It is satisfactory enough in the comparative study of the root systems of different varieties of agricultural crops.

(2) *Depth of roots.* Other conditions being similar, the tropical thick canes possess a root system distinctly shallower than those of the indigenous kinds, while differences are noticeable among the indigenous canes themselves. The varieties belonging to the Saretha group show a deeper root system than those of the Pansahi group. The members of the Mungo group often show a system as deep as those of the Saretha group, and this explains why some of these have been found to be drought-resistant in parts of Bengal, Bihar and Orissa. Plate XIX illustrates the dissimilarity in root development between Katha and Yuba belonging respectively to the Saretha and Pansahi groups. The larger and deeper rooted Katha is relatively more drought-resistant.

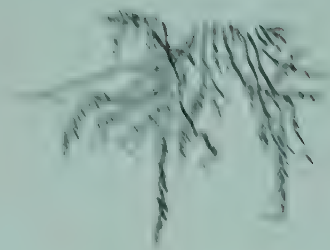
(3) *Habit of roots.* Besides the relative depths, differences have been noticed in what may be called the plan or the habit of the roots. Plate XX illustrates a few of these types as disclosed in a series of dissections carried out when the plants were three months old. Figs. 1 and 2 represent a comparatively smaller root system, the former being better distributed than the latter which consists of a more or less compact set of roots going vertically down. Figs. 3 and 4 show a larger system, the individual strands being thinner and sparser in 3.

Sugarcane root systems — influence of pollinating parent

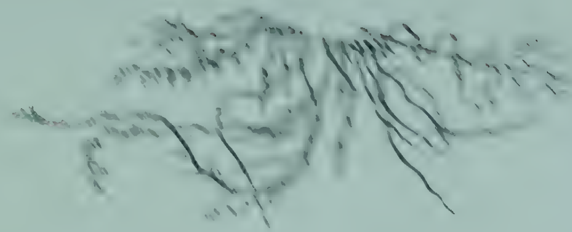
PLATE XXII



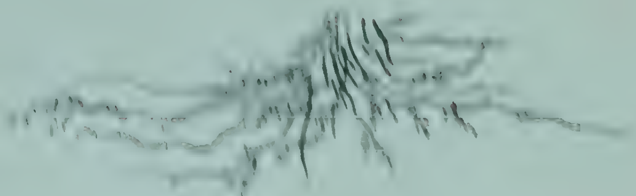
Vellai



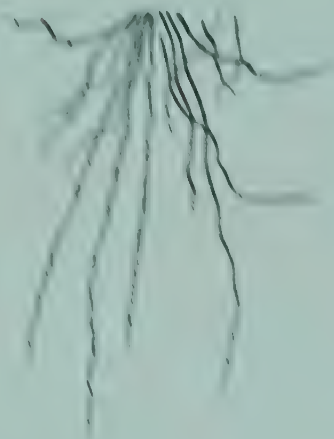
Ashy Mauritius



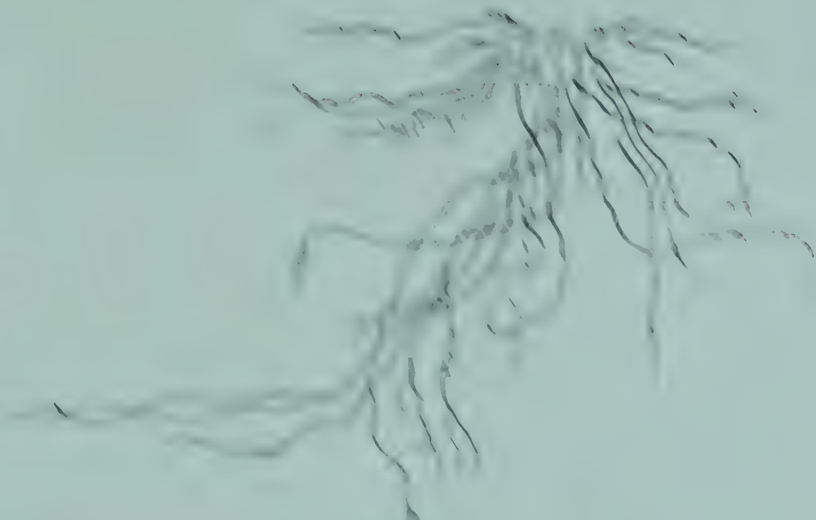
Vellai x Ashy Mauritius ♂



Vellai



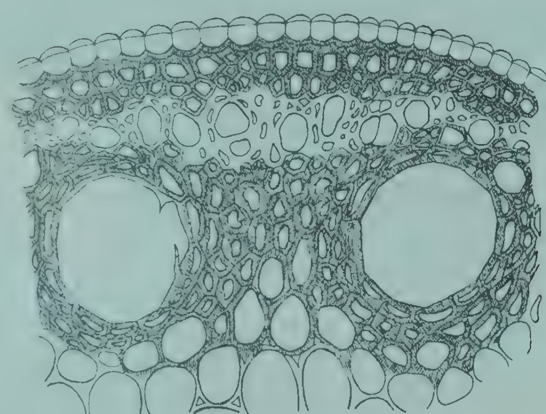
Saccharum spontaneum



Vellai x Saccharum spontaneum ♂

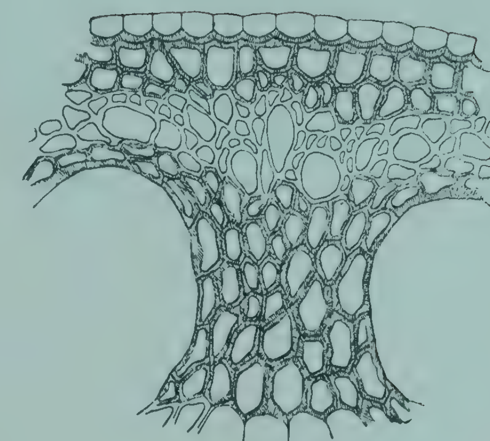
Structure of Roots — Sugarcanes —

(Transverse sections through young conducting region)



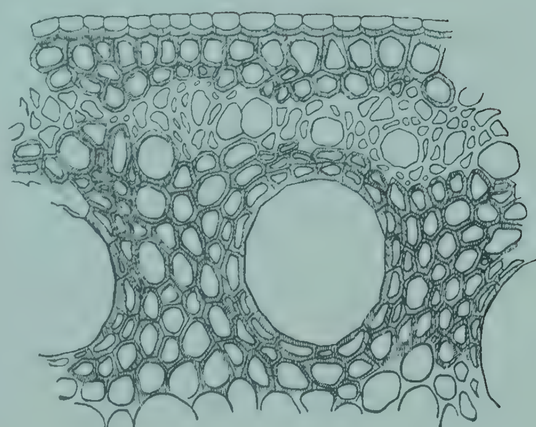
Chunnee

(1)



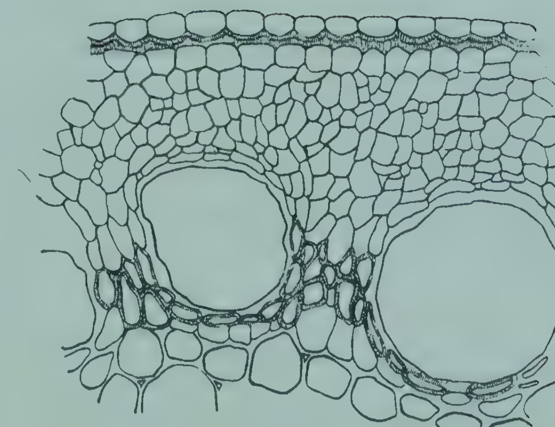
Yuba

(2)



Saharanpur White

(3)



Sewari

(4)

The depth and plan of root development described above bear directly on the level and cubic contents of soil tapped by the roots and are consequently of obvious importance in the cultivation of the different varieties. That the differences mentioned above are varietal, has often been borne out by their showing the characteristic differences not only when grown under similar conditions but under markedly different conditions as well. Plate XXI illustrates the root systems of two of the indigenous canes—Saretha and Chin—as dissected out in three of the Government farms in the United Provinces and in Coimbatore. It would be noticed that whereas there exist differences—chiefly in quantity of roots developed—between the systems of the same variety in the various places, those of Chin show in every case a deeper and more vertical development than those of Saretha.

(*d*) *Crossing in sugarcanes with a view to improve the type of root system.*

The utility of the above studies in sugarcane breeding lies in the possibility of introducing a desired type of root system by a suitable mating of parents. The study of inheritance of characters in sugarcanes is complicated by factors over which it has not been possible to exercise much control ; but in certain cases the writers have found it possible to introduce a desired type of root system in the resultant population by a suitable crossing. Plate XXII shows how in a series of crosses with the South Indian thick cane Vellai as mother the resultant seedlings have shown differences in agreement with the root systems of the pollinating parents. The grass *Saccharum spontaneum* possesses a very deep system and most of the seedlings with this blood in one or other of the parents have shown a comparatively deeper root system and proved relatively more drought-resistant both at Coimbatore and in the North Indian farms.

(*e*) *Certain anatomical features.*

These investigations have but recently been commenced. So far no marked differences have been noticed in the absorbing regions

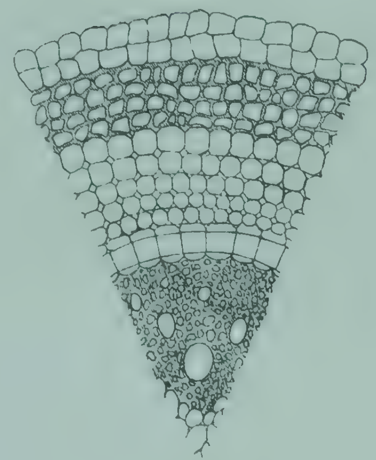
of the roots. The conducting regions have often shown differences according to the habitat of the variety.

Varieties growing under dry conditions have shown adaptations for protecting the ascending sap in the bundles. Such adaptations take the form of a pronounced thickening of the cell walls in (1) the cell layers immediately to the inside of the endodermis, (2) the layers of cells between the pith and the vascular region, and (3) the cells round the vessels. Plate XXIII, fig. 1 shows the anatomy of such a root, *viz.*, of Chunnee which is able to grow under dry conditions. It is interesting to compare it with that of Saharanpur White and Yuba grown under irrigation and with that of Sewari, a variety growing under rather marshy conditions round about Sepaya in Bihar. It has been ascertained that the thickening consists of both suberin and lignin, the former apparently to prevent the escape of the ascending sap and the latter for mechanical strength. Plate XXIV illustrates the anatomy of three grasses and three agricultural crops growing in dry, moist and waterlogged conditions. The parallelism is obvious.

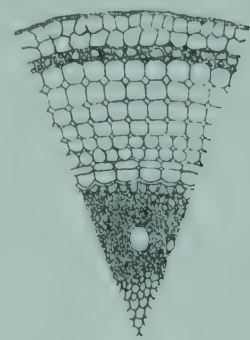
Some of the other anatomical characters in which differences have been noticed and now under study include (1) relative thickness and number of exodermal layers, (2) relation between the amount of cortex and stele, (3) relative quantity of intercellular space in the cortex, and (4) presence or absence of a pronounced thickening at the root hair tips.

Structure of Roots — Grasses & Agricultural crops.

(Transverse sections through young conducting region)

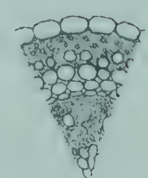


Aristida adscensionis

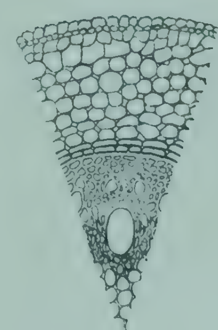


Chloris barbata

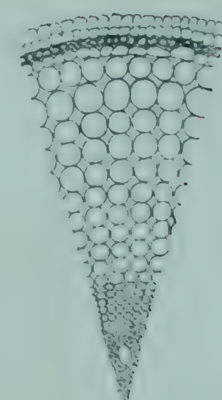
Cyperus Sp. (aquatic)



Setaria italica



Andropogon Sorghum



Oryza sativa

EXPERIENCE OF PRICKLY PEAR AS AN EMERGENCY CATTLE FOOD.

BY

N. V. HANMANTE, B.Ag.,

District Agricultural Overseer, District Kolaba, Bombay.

During the famine of 1918-19, in a period of extreme stress for fodder in the Eastern Deccan, a method was for the first time worked out which allowed the use of prickly pear as a fodder for cattle on a large scale, and which was successful in keeping the animals in health. The method used was described in a Bulletin[1] issued by Prof. J. B. Knight, in 1920, but still a good deal of suspicion remained with regard to the fodder, which required further demonstration on a larger scale to convince cattle owners as to its utility in famine periods.

The famine conditions which prevailed in the Ahmednagar District in 1920-21 gave the opportunity for a further demonstration of the value of prickly pear, and it was decided to run several cattle camps in the district. The camp at Rahuri, of which the writer was in charge, was run from the beginning with prickly pear as the principal rough fodder. It was started as a relief measure by the Collector of the district, the Agricultural Department of the Bombay Presidency being responsible for the management.

The bullocks for the camp were purchased in the surrounding bazaars at an average price of Rs. 19-4-0 per animal, though a large number was purchased at a much lower rate. The total number of cattle admitted into the camp was 1,583. The animals required a little breaking in before they were content to eat prickly pear as

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[1] *Bombay Dept. Agri. Bull.* 97 (1920).

their chief fodder, but in most cases they became quite accustomed to it within a week. The thorns of prickly pear were burnt off in the furnace (a modification of the village blacksmith's furnace) described in Prof. Knight's Bulletin, and then chopped into small slices. Various chopping devices were used, but most of the fodder was cut up in chaff-cutters. The chopped up prickly pear was then mixed with the requisite amount of cotton seed and fed to the animals.

The quantity of prickly pear consumed per day by a bullock, which was not accustomed to the diet, was from seven to eight pounds for the first six to ten days. After this period, the animal usually began to consume more, the maximum quantity eaten per day by an animal being as high as forty pounds. Even with this amount there was no derangement in the animal's digestion.

It is obvious that, owing to the extreme dilution of the food material in prickly pear, it cannot serve as a fodder alone, even as a maintenance ration. Furthermore, whenever attempts were made to feed it alone, the animals almost always scoured badly. In order, therefore, to supplement the nutrients in the prickly pear and to avoid the scouring action, two pounds of cotton seed and two to three pounds of dry grass were given daily to each animal.

The condition of the animals on admission to the camp was deplorable. There was, however, a rapid improvement when they were brought on the above ration, and after two months or so they became decidedly vigorous.

The animals were maintained in this way from the middle of February to the middle of June 1921, when they were sold to the cultivators of the district. In the meantime, the bullocks were used for various kinds of light and even heavy work. The whole of the carting of grass and foodstuffs for the camp was done by the bullocks fed on prickly pear. The prickly pear itself was brought by the same means from places five to six miles away, and the cultivation of an area of land attached to the farm, where green fodder was grown under irrigation, was carried on by the same agency. These facts disprove the local opinion that animals fed on prickly pear are of no use for work even when they are given concentrated foods with it.

EXPERIMENTS WITH A LIGHT MOTOR TRACTOR IN THE OEL ESTATE, KHERI.

BY

H. C. YOUNG,

Special Manager, Oel Estate, Court of Wards, United Provinces,

AND

B. C. BURT, M.B.E., B.Sc.,

Recently Deputy Director of Agriculture, Central Circle, United Provinces.

THE Kheri and adjoining districts in the United Provinces present one agricultural feature rarely found in other parts of the province in the existence of considerable areas of culturable waste land of excellent quality in excess of the cultivating capacity of the existing village population by ordinary methods. Such land is fertile when once brought into cultivation and presents few difficulties to modern implements; but its reclamation by the local method of shallow hand digging is extremely laborious and expensive. Since population shows no sign of rapid increase, no considerable expansion of cultivation can be expected except by the introduction of more modern methods. Nor is the problem limited to the area returned as "culturable waste," since it is the custom to abandon rice fields after a certain number of years, particularly near the larger river (the *ganjar* areas), and to allow them to tumble down to grass for an indefinite period necessitating, at present, hand digging prior to cropping. The reasons for this state of affairs are not altogether clear, but many of the villages are none too healthy during the monsoon and considerable areas of land are devoted to rough grazing. The system of lengthy fallows where land is plentiful is readily understandable, but the common occurrence in the grass land of leguminous wild plants, some of

considerable feeding value, possibly indicates a further reason for the practice. Nevertheless, as at present conducted, the system is wasteful of land and of effort, and it is abundantly clear that, with the assistance of modern implements at certain stages, the cultivator could control a larger holding and get a better return for his labour. Agricultural capital in these districts is scarce, and as the owners of the large estates would benefit by development it is clearly their function to lead the way.

Cattle, though numerous, are small, labour for ploughing is scarce and much of the land to be reclaimed is excellent for tractor ploughing, being much like English "lea" land. These reasons led to the decision to purchase an Austin tractor and suitable implements. The plough used was a Ransomes (R S L D–Y L) two-furrow self-lift plough, which was subsequently replaced by a three-furrow (convertible two-furrow) plough of the same type, with English general purpose bodies.

The first experiments were carried out with the assistance of Captain Lee (of the Austin Company) at a sparsely populated village Rehawa with an adult male population of some 50 souls possessing some 500 acres of cultivable grass land in fairly compact blocks. The demonstration was carried out on a block of about 350 acres of grass land lying along the north bank of the Ul River, including dense patches of *gandar* (*Andropogon* sp.), *kans* (*Saccharum spontaneum*), *patawa* (*Saccharum ciliare*) and other deep-rooted and obstinate reeds and grasses. The soil appears to be excellent light alluvium and, in the opinion of local cultivators, is capable of producing fine crops of rice, sugarcane, barley and wheat. But the density of the *kans* and *gandar* and the scarcity of labour make hand digging impossible. At the beginning of the operations the soil was moist and soft and the plough took up its work most efficiently, going through the tough reeds, which in places stood about 3 feet high, as if they did not exist and making a furrow from 6 to 7 inches deep and about 10 inches * wide. The soil was turned completely over and all reeds

* This could have been increased to 12 inches but the work would not have been so satisfactory.

Out of the 1,583 animals brought to the camp, most of them in very bad condition, there were 56 deaths in all in four months. Fifteen animals died on account of extreme starvation before they were brought to the camp, and the remaining forty-one from rinderpest which appeared no less than four times in spite of careful segregation of new animals. In the cases of deaths due to previous emaciation, post-mortem examination showed no injury to the alimentary canal as the result of feeding with prickly pear.

The daily average cost of food per animal in the camp, including the carting and preparation of the prickly pear, the cost of cotton seed, and the cost of the dry grass given, amounted to three and a half annas per day or Rs. 6-9-0 per month.

During the whole run of the camp, it was noticed that it was very difficult, if not impossible, to bring old and weak animals into good condition by means of the ration provided, but that those which had not already suffered from starvation could be maintained without deterioration and without much trouble. Young animals accustomed themselves to the food quickly, and flourished on it, even when emaciated before being brought to the camp. As a method of saving cattle in years of fodder famine such camps should therefore concentrate their energies on young animals which will much better repay the attention bestowed upon them.

Selected Articles

A NATIONAL POLICY FOR AGRICULTURAL RESEARCH.*

BY

RAYMOND A. PEARSON,

Of the Iowa State College of Agriculture and Mechanic Arts.

THERE should be a well-defined national policy in reference to agricultural research because such research relates to questions of fundamental national importance and the value of such research to the whole nation has been proved; furthermore, agricultural problems affecting the national welfare are becoming more and more numerous and complex and research must be enlarged to enable us to cope with them.

The policy should be to provide ample support for the investigation of problems relating to the decrease of cost of producing farm products and their more efficient distribution and marketing, the improvement of their quality, the conservation of soil fertility and the betterment of rural life.

The policy also should be to encourage co-operation of all public agencies engaged in agricultural research, and to provide for proper supervision,—enough of each to produce the highest possible efficiency and not so much as to hamper efficiency.

Sound arguments in plenty can be given to support these statements.

THE IMPORTANCE OF AGRICULTURE AS A FUNDAMENTAL INDUSTRY.

About forty per cent. of the population of our country is engaged in agriculture. There are nearly six and one-half million

* Read at the President's Conference on the Agricultural Situation, Washington, D. C. January 26, 1922. Reprinted from *Science*, 1421.

(6,448,366) farms, including nearly one billion (955,676,545) acres. Each farm is an independent unit, and the character of the homes on these farms has a profound influence on the character of our nation.

The value of farm lands is estimated to be over sixty-six billion dollars ($66,334,309,556). The value of implements and machinery is estimated to exceed three and one-half billion dollars ($3,598,317,021). The estimated value of live-stock is nearly eight billion dollars ($7,996,362,496). The total of these great investments is about seventy-eight billion dollars ($77,925,989,073).

The value of the annual production of our farms far exceeds that of any other industry. It is equivalent to the value of all manufactures over the costs of raw materials. The value of farm products exported from the United States has averaged over two billion dollars ($2,062,000,000) per year the past ten years and constituted an average of 44·4 per cent. of all domestic exports.

In brief, it is sufficient to say that agriculture is our largest industry; it furnishes practically all of our food, the material for all of our clothes, the raw material for the larger part of the manufacturing industries of the nation, about one-half of the gross earnings of the railroads of the country, a consumptive market for nearly one-half of all the manufactured products sold on our markets and, lastly, agriculture furnishes a constant stream of rugged people who quickly find positions of service in the great centres of population.

THE PRESENT ORGANIZATION FOR RESEARCH.

Research has been applied to all phases of human activities but research in agriculture has been relatively late in development. It came with a growing concern for the future of agriculture,—an appreciation that as long as man lives agriculture must be a permanent industry and as population increases agriculture must be increasingly efficient.

The policy of encouraging agricultural research started in the States. Agricultural experiment stations were established in

Connecticut and California as early as 1875, in North Carolina in 1877, and in fifteen other States prior to 1887 when the Hatch Act became effective. In 1906 the Adams Law was passed. Those two laws are formal acknowledgement by Congress that agricultural research is an important national question. Under each of these laws every State receives $15,000 annually for agricultural research, making $1,440,000 from the Federal treasury. State appropriations for the same purpose amount to about three million dollars annually. Research work in the States stimulated similar work in the Federal Department of Agriculture which is now by far the largest single organization conducting agricultural research. This department gives attention principally to problems of national or regional character, and engages in co-operative research work with the State experiment stations to a large extent. It would be impracticable for the Federal department to care for all the problems pressing for solution and wisely that is not attempted. The States are in intimate contact with their own problems and so far as funds permit give these problems prompt and usually sufficient attention.

The results of agricultural research.

The benefits of agricultural research are so well known that it is hardly necessary to mention them. For example : A farmer produced pork at a cost of forty-four cents per pound until he made use of information gained from research and then he reduced his cost to four cents per pound. Through instruction based upon research and widely disseminated to the farmers, one State has shown how to reduce losses from the Hessian fly to the extent of twenty million bushels of wheat in four years,—and all this at only a nominal expense. Research has made it possible to continue growing important crops in sections of the country where some pest or disease was turning the farmers' efforts to naught. About ten years ago the United States Senate showed that scientific research in the Department of Agriculture, costing about five million dollars annually, had resulted in saving about five hundred million dollars annually.

Books could be filled with interesting stories such as how the cause of wheat rust was discovered and a remedy applied and how Texas cattle fever was placed under control and is being surely eradicated and many other similar exploits. Add to all this the development of improvements of animals and plants and of agricultural methods generally.

Research is the foundation of our whole system of agricultural education in colleges and schools, through the Extension Service, and through agricultural journals and books. It also is the basis for regulatory laws and their enforcement.

It would be impossible to tell what would be the situation in this country if agricultural research had not been maintained. We know some of the most important improved varieties of plants and some of the better strains of animals would be missing. Some diseases of animals and food plants would be rampant. Great areas of soil now producing crops would be barren, and the production from still larger areas would be lowered. Farmers would be paying more for their supplies and some highly effective marketing methods would not be known.

More research is needed.

It is unfortunate that the research agencies of the country are unable to keep pace with the demands being made upon them. The experience of the past, the present situation, and a view into the future emphasizes the necessity of enlarging the system. A sound and efficient agriculture calls for more research. The development of some phases of agriculture, representing millions of dollars to farmers and to other citizens, awaits the enlargement of research activities. As the country becomes older and its population increases and quicker transportation is developed, new problems constantly appear. Some persons who are not informed think we are doing quite well at the present time and agricultural research might be kept on its present basis or even it might take a vacation for a few years. But the germs and the fungi now on their way to favourable locations throughout the country will not pause on their journey, and plant food will

continue to be depleted when crops continue to be taken from the soil.

Research problems might be divided into two great groups. The first would include the new difficulties that are constantly arising and must be overcome to keep agriculture in its present position, such as a new insect pest. The second would include such questions as the improvement of existing methods which means a better agriculture. Originally the second group of questions constituted most of the research work performed. More and more questions in the first group have been coming to the front in recent years until now they demand a very large part of the research resources.

New methods for reducing cost of production, the better distribution of farm products, and better methods of marketing are sorely needed at this time. This is in the interest of the average citizen who buys all his supplies, because such methods will help to reduce the cost of living. This is in the interest also of farmers because better methods will increase the profits of farming. Both benefits are worthwhile. But a chief reason for decreasing the cost of farm production is the importance of holding our position in the markets of the world. We ought to get a better hold upon those markets especially in so far as certain manufactured farm products are concerned. If we wish to sell to Great Britain at a profit we must be able to make a lower price than others can make. We used to export about one hundred forty million pounds of cheese annually, but before the Great War these exports had fallen to two or three million pounds. We like to say that we are not exporting cheese because our larger population is consuming it all. But why did not our cheese production increase with our population? The chief reason was that Canada could do better than we could do in making a favourable price on cheese in the English markets. The outcome of such competition depends largely upon the results of our research for superior and less expensive methods.

Our natural resources plus our skill plus our shipping ability are in competition with the natural resources of other countries plus their skill plus their shipping ability plus their cheaper labour

which involves lower living standards. If we are to win from them we must depend chiefly upon our superior knowledge. Some other countries have as good natural resources as ours. Sometimes they are even better because of virgin lands. Other countries have as favourable transportation. Most countries have cheaper labour. We must overcome their advantages by our knowledge which must be developed through research.

When we find an economy in feeding or some method of reducing cost per bushel or when we invent an improved harvester or perfect a silo, or when we find more direct and efficient methods of marketing, we are able to reduce our selling price and thus strengthen our hold on foreign markets. When we allow a mysterious disease or inefficient methods to increase the price we must ask whether we are losing our hold on foreign markets.

We must not forget that in other countries strenuous efforts also are being made to devise better methods through research in order to take the foreign markets away from us and even to invade our home markets. Thus far we have developed only a background of information regarding the great economic questions. We have hardly crossed the threshold in research concerning the adaptation of production to requirements and other such great economic problems.

Other vitally important subjects waiting to be studied as they deserve include the reforestation on farms and the betterment of rural life. There are many questions relating to the comfort and happiness of people who live in the country that are becoming constantly more acute. These include the whole sphere of the work of farm women. The failure to solve these questions is resulting in some of the best of type of farmers moving from the country to the city. Much needs to be done to show such people how to make country life as satisfactory as city life.

One other of many very important problems in need of research may be mentioned,—the conservation of soil fertility. This is the most important of our natural resources. It is easily removed but not easily replaced. We gather crops very much as we harvest lumber. Most people know how we have accomplished such an

enormous production of lumber during the past few decades. We simply went into the forests which had required hundreds of years to grow and we took the trees that were wanted and even gave scant consideration to the welfare of other trees which might have become useful in later years. We have not considered how succeeding generations will get their lumber. We have proceeded on the basis that we might as well take it all. We point to our lumber kings as examples of great business ability. What will be said of them fifty years from now when the people of that day want lumber and find that the accumulated growth of centuries over large areas has been destroyed by our generation and even without much effort to start new trees for use in the future? Our cereal production has been carried along on about the same lines. If present practices continue this nation will awaken some day to the fact that we are more like arid Egypt or Babylon than the wonderful, fertile country that our historians tell us was discovered by Columbus.

Furthermore, we are allowing many square miles of good farm land each year to be washed away by our streams. This erosion supplemented by surface wash amounts to hundreds of millions of tons annually. These losses represent stupendous values which doubtless could be largely reduced through further research.

No one can tell what wonderful improvements in agriculture may be revealed in the future. We easily think of possible further advances along the lines we know about but these may be made secondary by other advances that we cannot now even think of. Some persons believe that beneficial changes are yet to come in agriculture which are no less profound than the changes in transportation caused by the flying machine or in communication caused by the wireless telephone. Those two improvements are epoch making but were hardly within our range of thinking a generation ago.

I will not be so rash as to suggest that a tin Lizzie ever will give milk, but I will predict that some day power for the farm which now constitutes a chief item of expense will be obtained cheaply from the winds that blow over the farm. And with this cheap power

I predict that some day we will produce the best of building materials, at lowest cost, from almost any soil. It may be aluminum.

I will predict also that if our plant and animal experts are given reasonable support they will find, in good time, new and good foods now unknown, and if our economists and other experts are given reasonable support they will show how our cities may be assured of an abundant supply of farm products at all times and at cost reductions that will exceed previous cost reductions that have been so welcome to both farmer and consumer.

Development of a policy.

We should no longer delay the development of a more comprehensive national policy for agricultural research. It should provide for liberal federal and state financial support. The best recent testimony comes from the Congressional Joint Commission of Agricultural Inquiry (*Congressional Record*, December 14, 1921, page 421). Members of this Commission after a long and thorough study report as follows:

"Agriculture is subject to special hazards resulting from the weather and climatic conditions, animal and plant diseases and insect pests. These hazards reduce farming to a gigantic gamble. But methods of production can be adapted to the end of reducing losses from climatic and weather conditions to the minimum. Plant and animal diseases and insect pests can, to a certain degree, be controlled. But the means and the method of reducing or controlling these hazards cannot be worked out on the farm by the individual farmer. The investment even of the largest is not sufficient to permit the maintenance of the organization necessary for the study and formulation of these means and methods. A programme of agricultural development therefore must include provisions for an expanded and co-ordinated programme of practical scientific investigation, through State and National departments of agriculture and through agricultural colleges and universities, directed toward reducing the hazards of climatic and weather conditions and of plant and animal diseases and insect pests."

One strong reason for using public funds to support agricultural research is that the knowledge to be derived should be made available to every farmer throughout the country who wants it. It should never happen in this country that knowledge relating to agricultural production shall be limited in its application to private interests because it was developed at the expense of those interests. It may not be improper in other lines of business for individuals or concerns to have a monopoly on knowledge and thus enable them to develop a business monopoly. But this should never be possible in agriculture. A corner-stone of our national strength is the independent farm families who are able to maintain themselves on an independent basis because every farmer is entitled to know all of the secrets of his business that anyone knows.

Appreciation of agricultural research.

(1) What should be insured first in a national policy? Agricultural research needs first of all the appreciation and good-will of the public. Until this is given the research will be heavily handicapped.

Secretary of Agriculture Wallace declares that research is the basic work of his department and it is research that little by little is crystallized into agricultural progress. The public should get this idea. The Congress and legislatures should have it. An intelligent appreciation of agricultural research, especially among leaders and public men, a genuine respect for it, an understanding of its importance and its requirements, are the primary essentials in developing an effective national policy. Such an appreciation exists to-day but in a very restricted sense. Belief in the importance of research is too much of an abstract character, an acknowledgement that it is useful in a general way, an acceptance of the fact that it is desirable, but without real sympathy for it or understanding of its requirements. Thus the public fails to demand it in order that the nation's interests may benefit. One thoughtful student gives as one of the reasons for advocating national support for agricultural research the fact that national appreciation needs the stimulus of direct interest which comes with the discussion of the subject

in the halls of Congress and the making of an appropriation. There are, however, other and better arguments.

An intelligent appreciation of agricultural research is not evidenced in any large way by the recent action of Congress, let us say a very few members of Congress, by which the publication of two periodicals in the interest of agricultural research was suddenly ordered discontinued along with a lot of other publications of questionable value, most of which had developed during or soon after the war period. There is encouragement in the fact that some leading members of Congress were not informed as to what was occurring but now realize that a serious mistake has been made and are ready to help correct it.

Essentials for research.

Well trained men and ample funds are the essentials for research. It should be a national policy to train and encourage in every way possible the right kind of men and women and to supply funds to meet their reasonable needs in research work in the interest of agriculture.

(2) Efforts should be made always to encourage young men and women who have ability and inclination of the right kind, to prepare themselves for research work. Special scholarships and fellowships should be provided by the agricultural educational institutions to enable such persons to complete their fundamental training and later assistantships should be provided to bring them into helpful contact with older and well-trained investigators and due credit should be allowed for their own efforts. As they advance in ability and in getting worthwhile results their compensation should be reasonably increased. Care should be taken to make this compensation as attractive as is provided for persons of corresponding ability and service in allied lines of work. Failure in this respect in recent years has resulted in heavy losses from the ranks of research workers in the Department of Agriculture and in State experiment stations. During a period of about six years, including the war, there was a change of nearly eighty per cent. in the scientific personnel engaged in agricultural research throughout the country.

Many of the younger men went into war service, but the greater losses to agricultural research came from the resignation of older men who took other more remunerative positions. The overturn has been exceedingly large since the war. On this account, and without reflection upon those who have continued in research work or who have recently gone into that work, it must be admitted that research to-day, instead of being the strongest link in the chain made up of research, college education, and extension work, is the weakest link. Research is the least able of the three to meet the demands it should care for.

Funds for the support of agricultural research as now available represent such a small percentage of the interests concerned that they are almost negligible by comparison. They represent a much smaller per cent. of value of output than is so expended by many a manufacturing plant in the interest of its output.

(3) A principal requirement as to funds is assurance of permanent income. Without such assurance strong men cannot be induced to prepare themselves adequately for research nor can they be retained in this work. Too often it has been necessary to stop important experimental work because of failure to continue appropriations. No one can tell what losses have been suffered because important projects after being conducted for an extended period of time had to be discontinued with the failure of appropriations before the final results had been secured.

(4) As agricultural research relates in such large measure to national problems and the work done in one State is of value in many States and as agriculture is such a large factor in all business, it is right that national funds should be used in promoting agricultural research in the different States. A precedent has been furnished, and a national policy for agricultural research should provide for enlarging these national appropriations by small increments for a few years until they have reached amounts commensurate with present demands, as specified in the Purnell Bill, which would provide fifteen thousand dollars annually additional to each State for experiment station work and an additional ten thousand each year until the amount is eighty-five thousand dollars. These

appropriations would be equivalent at the start to less than one cent *per capita* per year and would finally increase to about four cents *per capita*. This measure, or other similar relief, should be enacted as soon as possible. It is preferable from the standpoint of efficiency to make the appropriation with the fewest possible conditions, as was done in the Hatch and Adams Acts, rather than to continue the requirement for offset funds, as provided in the Smith-Lever and Smith-Hughes Acts. As compared with the Federal Government it seems that the States now are carrying their full share.

In considering appropriations for agricultural research it is well to remember that when our taxes are increased for this purpose our involuntary taxes, or those which are levied by powers beyond our control, are decreased many times more than the voluntary taxes are increased.

Co-operation and supervision.

(5) A national policy fostering agricultural research should provide for more definite and constructive co-operation by research agencies than now obtains.

(6) It must provide also for certain supervision to assure the proper use of public funds, and this is expected and welcomed. A reasonable amount of co-operation and supervision is stimulating. An excess is deadening.

(7) A more definite agreement on the fields to be occupied by the Department of Agriculture on the one hand and by the State experiment stations on the other hand, with better co-ordination of work and a larger provision for joint effort, should form a part of the policy for further developing agricultural research. Such a definition of function and joint effort would guard against undesirable duplication and would result in better directed efforts. Details should be worked out by representatives of the Secretary of Agriculture and the agricultural colleges and when properly approved should form a fundamental law. Once each year this joint agreement should be considered by duly chosen representatives for the purpose of making it more perfect. Among other things, it should provide for the wise selection of projects for investigation

and for inviting experiment stations in different States or the Federal Department of Agriculture to give attention to different phases of a project requiring investigation at different places. All projects should be briefly but clearly described and recorded in the Department of Agriculture at Washington and all interested persons should be informed as to the kinds of work in progress. From time to time, at least once a year, the progress of each project should be officially reported and checked. When a project is undertaken, work on it should continue to a reasonable extent until it is finished or formally set aside, and care should be taken not to provide for starting new projects for any laboratory or station when it has too many projects unfinished.

(8) While a national policy for agricultural research should not enter the details of local administration, it should encourage the types of organization which would be most efficient.

Shall we have ample agricultural research ?

An effort has been made to suggest a picture of our country as it would be without properly supported agricultural research, and again with such research. If this work is properly developed, agriculture will continue on a permanent and profitable basis in the face of ever increasing obstacles. And this nation with a strong agriculture will continue to furnish its own great commodities which come from the farms and will profit further from large sales of the surplus in other countries. The time is ripe for stimulating a national policy for agricultural research which will contribute to this great end.

THE QUESTION OF THE DISTANCE BETWEEN CANE ROWS.*

A BRIEF RÉSUMÉ AND SOME ADDITIONAL DATA.

BY

ARTHUR H. ROSENFELD.

THE latter part of 1920 the author published in the *International Sugar Journal*, under this same title, a résumé of the experiments in all parts of the sugar-producing world on the width of cane middles. A few months ago Dr. W. E. Cross published in the *Revista Industrial y Agricola de Tucumán*,[1] the official organ of the Tucumán (Argentina) Sugar Experiment Station, the results from another crop of the plats of four distinct varieties which are being tried out with varying distances between the rows. It has been thought advisable to include these results, which it may be said *en passant* only verify the conclusions already reached in the previous paper, in a short review of this important subject, thus bringing the matter completely up to date.

As we pointed out in the earlier article on this subject, for each kind of plant and soil there should exist a theoretical maximum of the agricultural yield obtainable, or, in other words, each class of soil in each and every climate is capable, under ideal conditions, of producing an exact maximum of—let us say well developed sugarcanes, for example, and this maximum can be obtained only under optimum climatic conditions and with perfect cultivation. Also, most naturally, this maximum will be secured only through an ideal spacing of the plants which will allow each one to attain its *maximum development* and each unit of area to produce

* Reprinted from the *International Sugar Journal*, 1922, XXIV, pp. 72–76.

[1] Distancia a que se debe plantar la cana de azúcar.—Tomo XI. Nos. 9-10.

the largest possible number of *thoroughly developed* canes. Hence it is logical that too small a space between our cane rows must inevitably result in too large a number of *subnormal* canes, while excessively wide middles will probably produce splendid *individual specimens* of sugarcanes, the reduced number of which will fail to give the tonnage obtainable from the theoretically ideal number of plants of *normal* development. All experiments on the subject are, naturally, aimed at determining for distinct zones and distinct varieties just the spacing which will produce the largest *per acre* yield at the smallest *per ton* cost.

TABLE I.

Composite results of early Louisiana experiments.

Width of middles	No. of stalks per hectare	Average weight of stalk	Cane per hectare	CHEMICAL ANALYSES OF JUICE				Number of crops
Ft.		Grm.	Metric tons	Brix	Sucrose	Glucose	Purity	
3 ..	75,010	1300	85·0	14·2	10·7	1·53	75·35	14
4 ..	68,150	1250	79·2	13·9	10·4	1·62	74·82	14
5 ..	69,800	1300	82·5	14·0	10·6	1·54	75·72	18
6 ..	66,334	1300	82·1	14·0	10·7	1·66	76·43	12
7 ..	66,371	1250	82·0	14·3	11·0	1·66	76·92	6
8 ..	62,286	1350	78·1	13·8	10·3	1·72	74·64	6

In the previous article attention was first called to the classic experiments made by Dr. W. C. Stubbs in Louisiana in investigating this point, these experiments dating back to 1888.[1] Table I is a composite of the results of all of Stubbs' distance experiments, as shown in Tables I—VI of our earlier paper. These experiments were all made with the Louisiana Striped and Purple canes (*Cheribon*) and the cane planted in rows 3 ft. apart gave uniformly the best tonnage per hectare, although the increase over the 5 and 6 ft. rows would work out at only about one ton per acre—not sufficient

[1] Sugarcane : Results in Field and Laboratory in 1890. *Bull.* 14, 2nd Ser.

to compensate for the additional plant cane required for the more narrowly spaced rows, particularly as cane is seldom carried beyond first year stubble in the Pelican State.

The lowest yield per hectare has been given by the 8 ft. rows, which is manifestly an impossible spacing for this type of cane at any rate, on account of the large number of late cultivations necessary for weed elimination after the narrow spaced middles are entirely covered by the almost overlapping cane and, also, because very widely spaced cane offers less physical resistance to frost than closer-grown plants and this is an important consideration with Louisiana's adverse winter climate.

It is notable, too, that the 8 ft. rows, contrary to general opinion, have given cane of the lowest sugar content and purity and highest glucose ratio. There can be no doubt, however, in the mind of any observant person closely associated with sugar-cane that this huge grass is a *sociable* plant and develops best under normal conditions of spacing. The rapidity with which any very much thinned out canefield will entirely die out is a common observation among cane agriculturists.

After the 8 ft. rows the 4 ft. ones give consistently the poorest results in all of these Louisiana experiments. As no implements could be got between the 3 and 4 ft. rows no cultivation was given these middles in any case, and it is probable that, while the additional number of rows per hectare with the 3 ft. rows compensated for this lack of cultivation, this was not the case with the 4 ft. rows. It is likewise noticeable that the 4 ft. rows also gave juices of second lowest quality throughout. As between the agricultural yield or analyses from the other three series there is very little indeed to choose, and the conclusion is obvious that, considering the increasing number of light cultivations necessary with widening middles, the logical procedure indicated by these results is to select the narrowest middles consistent with the entrance of proper cultivating machinery, since, in these days of increasing labour troubles, a return to the old methods of hand cultivation is totally unthinkable. Mechanical cultivation is efficiently accomplished in 5 ft. middles, and these rows close sufficiently early under normal

conditions to make a great number of light middle cultivations unnecessary.

Up to the time of the above-described experiments most Louisiana planters used 6 ft. rows. but 5 ft. rows were almost universally adopted after the results of these extensive tests had been published and discussed by Stubbs.

There is a fairly steady increase in number of stalks per hectare. as is to be expected, as the width of the middles decreases and the number of rows per hectare increases and in this connexion Stubbs makes an interesting and pertinent observation. He found. after counting the number of canes per row at the time of throwing the first dirt to the cane, at lay-by and at crop, that many canes perish due to lack of space for growth. This was particularly notable in the stubble cane with narrow middles, the counts demonstrating that 50 per cent. of these canes had died before reaching maturity. Many canes measuring 3 ft. in height were found dead at crop time from no other apparent cause than the lack of room for development. This observation explains how it often occurs that a poor stand of plant cane may produce fairly good stubble, particularly with strongly ratooning varieties.

In Hawaii, R. E. Blouin,[1] after his 1901 experiments with the Lahaina cane, planted at 4, 5, 6 and 8 ft., showed that the 5 ft. rows produced 60 tons more cane per hectare than the 6 ft. rows, which occupied second place, concluded that the Hawaiian planters—who almost universally employed 5 ft. rows—had no reason whatsoever for deviating from this practice. Reynoso gives the ideal distance between Cuban rows as 5½ ft. and Boname concluded that 4½ to 5 ft. was best for Guadeloupe. Large sub-station experiments under the author's direction in Tucumán Province, Argentina, with Cheribon Striped and Purple with rows at 5, 6, 7 and 8 ft., showed by far the best yield for the 5 ft. rows, which gave 24 metric tons more cane per hectare than the 6 ft. rows and a gradual decrease in yield per hectare as the rows were placed farther apart, the 8 ft. rows giving by far the smallest yield.

[1] *Hawaiian Sugar Planters' Experiment Station Bulletin* 7.

A calculation of the financial gain —always the prime consideration in any agricultural experiments —with the 5 ft. rows over the 8 ft. ones, based on the price of cane to the planter at the time the experiments were made (1913), showed an advantage of $168·00 (U.S.) per hectare.

In 1917, 1918 and 1919 the writer conducted a large series of experiments, covering some one hundred and twenty acres, at the Santa Ana sugar factory in the Province of Tucumán, near where the substation distance experiments had been located, with 5, 6 and 6⅔ ft. rows, the 5 ft. rows averaging over 20 tons more cane per hectare per annum than the wider spaced rows. These experiments were made with the erect-growing P.O.J. 228 cane.

The substation experiments at Monte Bello and the Santa Ana tests, being both on a very large scale and in the same district, may properly be averaged, the results for the 5 and 6 ft. rows being shown in Table II.

TABLE II.

Average results from four crops at Monte Bello and Santa Ana. 1913-1917.

Width middles, feet	Metric tons cane per hectare
5	55·7
6	42·8

TESTS AT THE TUCUMAN SUGAR EXPERIMENT STATION.

The experiments at the Tucumán station were commenced in 1910 under the direction of Mr. R. E. Blouin and continued by the author until 1916. Since that time Dr. W. E. Cross, who succeeded the writer as Director of that institution, has continued the experiments up to the present time. The author is very much indebted to Dr. Cross for the data in these pages relating to experiments at the station since 1916.

The first series of experiments was made with Purple Cheribon cane and ran through first year stubble. The 4 ft. rows led in production per hectare, being followed by the 6 ft. ones by a small

margin. The 3 ft. rows averaged about 2 tons more cane per hectare than the 5 ft. rows, which were far ahead of the 7 and 8 ft. rows in production per hectare. Blouin[1] concluded from these experiments that, considering the important question of proper mechanical cultivation, the distance between cane rows in the Province of Tucumán should not be less than 5 ft. nor more than 6, recommending $5\frac{1}{2}$ ft. for the type of cane then in use in the Province.

About this time, however, the heavily-suckering, rapid growing and somewhat frost-resistant Java canes, P.O.J. 36, 213 and 228, had begun to attract wide attention in the Argentine sugar district, and in 1915 the author commenced a series of distance experiments with the P.O.J. 36 variety. The following year another series was initiated with the P.O.J. 213, a variety of very distinct type of growth from the P.O.J. 36, the latter being much more erect and having much less tendency to fall late in the season in times of very heavy rainfall. In 1916, also, experiments were begun with the now famous Kavangire (Uba) cane and with another variety of the bamboo type, which was imported into Louisiana from Japan by Stubbs and thence to the Tucumán Sugar Experiment Station by Blouin—called Zwinga.

In our previous paper results were given for four crops from the P.O.J. 36 series (one of plant and three successive stubble croppings) and for three crops each from the original P.O.J. 213, Kavangire and Zwinga plantings. Cross has now published[2] the 1920 results from these four series of experiments with extra-prolific types of cane, the results in each case thoroughly confirming the conclusions already reached in our earlier article—so much so that, instead of studying in detail the results from the individual series, we have averaged the results obtained from five crops of the P.O.J. 36 and four each of the P.O.J. 213, Kavangire (Uba) and Zwinga in a composite table showing the results from the two distinct classes of cane—the Java and bamboo types—

[1] *Revista Industrial y Agricola de Tucumán,* Ano III, pp. 474–477, 1913.
[2] *Loc. cit.*

during the years that they have been under trial at the Tucumán Station.

TABLE III.

Composite results from seventeen crops of P.O.J. 36 and 213, Kavangire and Zwinga, 1915-1920

Distance between rows	Stalks: Per row. 100 metres	Stalks: Per hectare	Stalks: Average weight	Cane per hectare	Sugar per hectare	Number of crops
			(A) Java canes			
Ft.			Grm.	Metric tons	Kg.	
3 ..	930	103,222	568	58·9	5578	9
4 ..	1190	99,000	605	60·1	5796	9
5 ..	1374	91,766	633	57·8	5527	9
6 ..	1587	88,361	657	57·8	5736	9
7 ..	1809	86,143	693	57·9	5707	9
8 ..	1973	82,479	671	54·9	5674	9
			(B) Bamboo canes			
3 ..	1808	217,500	309	61·3	3338	8
4 ..	2302	191,792	330	62·7	3444	8
$5\frac{1}{3}$ ..	2776	173,469	351	60·0	3349	8
$8\frac{1}{3}$ ..	3856	154,220	396	59·7	3696	8

With the exceptions of the plats planted at 8 ft. or over, the yields of cane per hectare in each of the two series vary so little between themselves at the different distances as to fall well within the limits of permissible experimental error, the extreme variation in yield of cane per hectare being under three tons (about one ton per acre). In each series the average weight of the individual stalks varied directly with the widths of the middles and it is also apparent from the sugar yields, as with our previous experiments, that the distance of planting exerted no appreciable effect on the sugar content or purity of the juices.

The number of stalks per hectare in both series increases, as is to be logically expected, inversely with the width of the middles and this point is of more than academic interest, since, as Cross points out, the decreased average weight of stalk in the closely planted rows is due entirely to decreased thickness of the canes, and this signifies a greater number of canes *per ton* to be cut, stripped and topped in the field as the middles are narrowed. This, naturally, means more time and expense in handling, and should be taken into serious consideration in deciding on the distance to be given the rows.

Conclusions.

After going over the entire subject and considering the results of recent experiments, our conclusions may be expressed in exactly the same terms employed in concluding our earlier article on this subject, *viz.*: "We may safely conclude that sugarcane should be planted in rows just as close together as is consistent with proper cultivation with modern machinery, this distance appearing to be about 5 ft. for the thicker type of cane such as the Cheribon, Lahaina, B 208, etc., and from 5½ to 6 ft. for the more abundantly suckering types such as the Java canes, the Uba, the Bamboo class, etc."

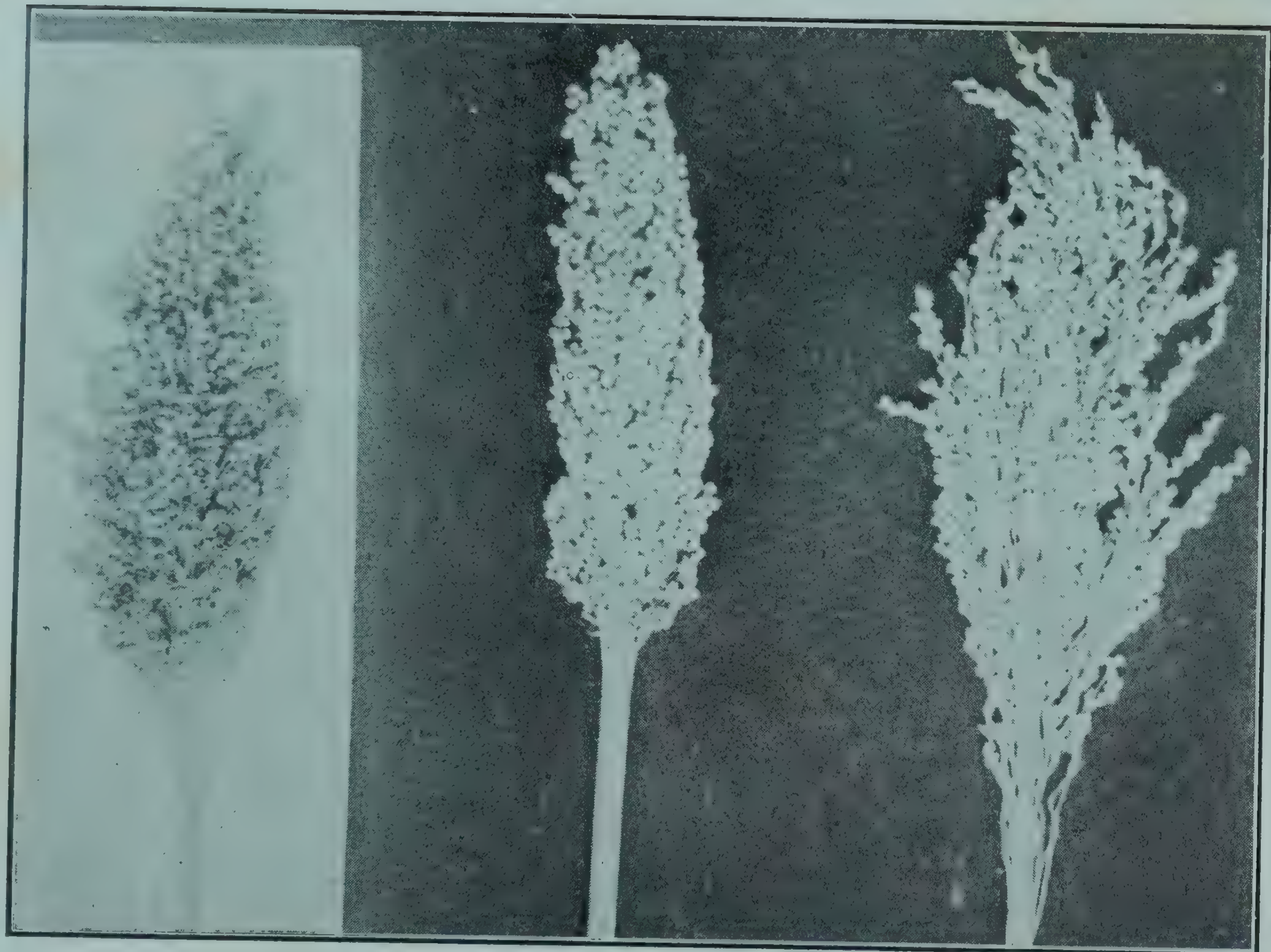

Fig. 1.

(*a*) Cross. (*b*) Nandyal. (*c*) Chowri.

Fig. 2.

Ear protected on the plant.

CROSS-FERTILIZATION IN JOWAR (*ANDROPOGON SORGHUM*).

Notes

CROSS-FERTILIZATION IN JOWAR *(ANDROPOGON SORGHUM)*.

FIELD observation shows a gradation of types in most fields of *jowar* which indicates the probability that cross-fertilization occurs freely. Near Dharwar (Bombay Presidency) a fairly compact headed variety called Nandyal is commonly grown as a main crop, with Chowri, a loose panicled variety, surrounding it on the borders of the field. Nandyal has a long rachis, carrying many short erect branches. Its grain is yellowish white in colour: Chowri has a long rachis bearing a few long and hanging branches and its grain is milky white. These types are illustrated in Plate XXV (Fig. 1*b*, *c*) and fall under groups 1 and 2 of the classification worked out by one of us.[1]

These varieties are very distinct in appearance. Intermediate types are easily distinguishable from the parent type, and a cross once made by the senior writer gave an intermediate type with brown grains exactly similar to that illustrated in Plate XXV (Fig. 1*a*). We have not worked with pure lines, but consider the results of our observations instructive as preliminary work and as throwing a good deal of light on the extent of natural cross-fertilization, as affecting the practicability of keeping a variety pure.

It is natural to assume that cross-fertilization will occur to different extent in different varieties, and that the crossing of different varieties will be largely influenced by their distance apart and by the direction of the wind prevalent with reference to the

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[1] Kottur, G. L. Classification and description of *jowars* of the Bombay Carnatic. *Bombay Dept. Agri. Bull.* 92.

position in which they are sown. Stigmas protrude from the glumes before the anthers and are thus exposed to pollination from other plants, but against this natural provision for cross-fertilization is the fact that the flowers from the tip of the panicle are earliest to open and provide pollen for the lower flowers. The crossing of varieties is thus not as extensive as would seem to be probable from a casual observation of the habit of the plant, and the growers succeed in keeping varieties much purer than the methods of cultivation would at first sight lead one to expect.

Graham[1] working at Nagpur estimated the percentage of natural cross-fertilization in a loose panicled type as six per cent. and in a type with a compact panicle 0·6 per cent. One variety gave 20 per cent. of crossed flowers.

Our observations refer to the probable extent of contamination of a field of one variety by pollen from another variety grown along its margin. A field of Nandyal and Chowri as described above was selected, in which both varieties were nearly pure. Thirty-two typical Nandyal ears were selected from all parts of the field and seed sown with the following results as judged by the numbers of intermediate types with brown grain appearing. These types are likely to be mostly F_1 crosses though not necessarily so, since the parents were not pure lines.

No. of the selected ear	No. of plants raised	No. of crossed plants found	Percentage of natural crossing
1	226	27	11·9
2	279	4	1·1
3	280	24	7·5
4	237	21	8·8
5	167	3	1·6
6	184	6	3·7
7	183	3	1·6
8	191	5	2·6
9	212	35	11·7
10	218	9	4·1
11	219	7	3·1
12	169	2	1·8
13	277	1	0·3

[1] Graham, R. J. D. Pollination and cross-fertilization in the *jowar* plant. *Mem. Dept. Agri. India, Bot. Ser.*, VIII, 4, p. 205.

No. of the selected ear	No. of plants raised	No. of crossed plants found	Percentage of natural crossing
14	226	9	3·6
15	227	6	2·6
16	225	3	1·3
17	224	9	4·0
18	250	0	0·0
19	268	3	1·1
20	228	2	0·9
21	270	0	0·0
22	249	4	1·8
23	247	4	1·8
24	243	5	2·9
25	203	9	4·5
26	306	35	11·1
27	251	3	1·1
28	246	3	1·2
29	224	3	1·2
30	326	33	10·1
31	252	3	1·1
32	309	22	7·1

The proportion of intermediate types from different ears varied from 0 to 11·9 per cent. according to the following table, which shows the frequency of varying amounts of admixture in the produce from 32 plants.

Class (percentage)	Frequency
0	2
0·1 to 1·0	2
1·1 to 2·0	12
2·1 to 3·0	3
3·1 to 4·0	3
4·1 to 5·0	3
5·1 to 6·0	0
6·1 to 7·0	0
7·1 to 8·0	2
8·1 to 9·0	1
9·1 to 10·0	0
10·1 to 11·0	1
11·1 to 12·0	3

Only two out of 32 gave no intermediates. The varying distances which separated the parent plants obviously must account largely for the varying frequency of contamination, and this is a point which requires further investigation. Its bearing on the practical side is very important.

We are continuing our observations on this problem by working primarily to establish pure lines. Our method of protecting the ears is to cut the sheath enclosing the ear, and to cover it with a cloth bag supported on wire rings (Text-figure), as illustrated in Plate XXV, fig. 2. We have found paper bags unsatisfactory, because they break if rain comes. Unsupported cloth bags induce a mould growth. Bags supported as described are absolutely satisfactory.

The ring for insertion in the bag.

[G. L. KOTTUR AND R. K. KULKARNI.]

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A CHEAP AND EFFICIENT METHOD OF PROPPING SUGARCANES.

MANY cane farmers, chiefly those growing the thicker kinds, are forced to use supports for their canes to prevent "lodging." This need is particularly felt in light soils where the shallow root system is unable to support the weight of a heavy crop when high winds are blowing. As lodging not only renders the harvesting of the crop difficult but also reduces the manufacturing value of the cane, practical farmers have evolved various methods of propping the canes. A particularly elaborate and costly system obtains in the Godaveri delta of the Madras Presidency where the cost of this operation per acre sometimes runs to as much as Rs. 80.

In the Sugarcane-breeding Station at Coimbatore, where, for a correct estimation of the sugar value of a seedling, it is essential that the canes should be carefully guarded against lodging, the writer has adopted, with considerable success, for the last two seasons, the following method.

When the crop has developed two to three feet of cane, bamboo verticals are planted along the rows at distances of ten to twenty feet according to needs. The actual distance will vary in different tracts according to the kind of cane grown and the quality of bamboos available. Plain drawn galvanized iron wire—the writer uses 18 gauge * but a thicker or thinner wire may be selected to

* Towards the end of last year 10,000 feet of this wire cost Rs. 40.

A CHEAP AND EFFICIENT METHOD OF PROPPING SUGARCANES.

suit local conditions—is next passed round the canes and the bamboo verticals as illustrated in Plate XXVI. The wire is made to form figures of eight, resulting in a supporting strand on each side of the canes.

For convenience of handling, the wire is cut to short lengths, separate loops being formed of each. At the station the cane rows are standardized to 20 feet lengths, and the wires are accordingly kept in loops of 40 feet each. In larger plantations the wires may be cut to greater lengths. When the loop is formed, the two ends are twisted into a knot in front of one of the end bamboos as shown in the picture. This loop is prevented from slipping down by means of a supporting nail driven into the end bamboo at a suitable height. The illustration is of a cane plot at the Coimbatore Station. It shows diagrammatically in the front row two loops of wire, each passing round 3 bamboo verticals and covering a 20 feet distance of the row.

When the crop has grown much beyond the supporting strands as to render them inefficient, the wire loop is slipped upwards and kept in position by means of fresh nails driven into the bamboos. For thin canes growing to a height up to 12 feet one such supporting loop is found sufficient but, with a taller crop or heavier canes, two loops or a thicker wire may be required.

At harvest the loops are slipped up to a convenient height when the canes can be easily cut and pulled out. The wires are collected after the removal of the bamboo verticals and kept in bundles of 20 to 30 loops, the loops being kept more or less taut on bamboos fixed at the right distance in the place of storage. The wires, however, do not remain long in the stores as they are soon required for the succeeding crop.

Experience during the last two seasons has demonstrated the cheapness and efficiency of the method. At the Cane-breeding Station, where the propping has to be done more carefully than in an ordinary plantation, tying with trash or with rope at frequent intervals used to cost Rs. 80 per acre but the expense on the improved method should not work out more than Rs. 35 per acre per annum. In making the above calculation it has

been assumed that both the bamboos and the wires will last five years.

With the supporting strand on each side of the cane row, which can easily be adjusted, lodging is effectively prevented. The method especially provides against lodging from the very commencement. It is not uncommon to be suddenly caught after a portion of the field is lodged. Lodged canes, even when carefully supported and propped afterwards, do not recover completely. [T. S. VENKATRAMAN.]

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PRODUCTION OF REFINED SUGAR BY MODERN REFINERIES IN INDIA DURING THE WORKING SEASON OF 1921.

IN India there are at present 18 factories refining raw sugar, *gur* or *rab*. Four of these are situated in the province of Bihar and Orissa, 8 in the United Provinces, 4 in Madras, 1 in Mysore and 1 in Bengal. The following totals have been obtained from enquiries instituted by the Sugar Bureau as to the quantity of *gur* and raw sugar melted, sugar made, and molasses turned out by these factories during the working seasons of 1920 and 1921 :—

	Year 1920	Year 1921
	Mds.	Mds.
Gur and raw sugar melted	2,212,817	2,471,026
Sugar made	1,211,274	1,324,646
Molasses obtained	723,965	870,704

The higher figures for the season 1921 are largely due to the fact that two factories commenced refining *gur* for the first time and returns were received from two factories which did not furnish similar information for the previous season.

A study of the returns submitted by individual factories shows that there is a wide variation in the percentage of recovery of sugar from the raw material dealt with. In Northern India where the refining *jaggery* is of an inferior value, the recovery of sugar varies from 35 to 45 per cent. according to the efficiency of the factory.

In Southern India, where the quality of *gur* melted is superior, better results are obtained.

A note published in the issue of the *Agricultural Journal of India*, January 1922, gives the total quantity of sugar and molasses produced by factories making sugar direct from cane for the years 1919-20 and 1920-21 as follows :—

Year			Sugar made	Molasses obtained
			Mds.	Mds.
1920-21	..	..	669,291	404,712
1919-20	..	..	628,920	370,953

The total refined sugar production thus amounts to 1,993,937 * maunds or 73,113 tons in the season 1920-21 as compared with the total production of 1,840,194 * maunds or 67,476 tons in the previous season. [KASANJI D. NAIK.]

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COTTON TRANSPORT BILL.

THE following Bill was introduced in the Legislative Assembly on the 8th March, 1922 :—

No. 15 of 1922.

A Bill to provide for the restriction and control of the transport of cotton in certain circumstances.

WHEREAS it is expedient for the purpose of preventing the mixing of inferior with superior varieties of cotton to provide for the restriction and control of the transport by rail and the import of cotton into certain areas ; It is hereby enacted as follows :—

Short title and extent.

1. (1) This Act may be called the Cotton Transport Act, 192 .
(2) It extends to the whole of British India.

* Includes some raw sugar imported from abroad and refined locally.

Definitions.

2. In this Act, unless there is anything repugnant in the subject or context,—

(*a*) "certified copy," in relation to a licence, means a copy of the licence certified in the manner described in section 76 of the Indian Evidence Act, I of 1872, by the authority by which the licence was granted ;

(*b*) "cotton" means all unmanufactured cotton, including cotton either ginned or unginned, cotton waste and cotton seed ;

(*c*) "cotton waste" means droppings, strippings, fly and other waste products of a cotton-mill other than yarn waste ;

(*d*) "licence" means a licence granted under this Act ;

(*e*) "notified station" means a railway station specified in a notification under section 3 ;

(*f*) "prescribed" means prescribed by rules made under this Act ; and

(*g*) "protected area" means an area into which the import of cotton has been prohibited by a notification under section 3.

Power to issue notification prohibiting import of cotton into protected area.

3. (1) The Local Government may, for the purpose of protecting the cotton grown in any area in the Province from being mixed with cotton of an inferior variety, by notification in the local official Gazette prohibit the import of cotton into that area save under, and in accordance with the conditions of, a licence.

(2) Any such notification may prohibit the delivery to, and the taking of delivery by, any person, at any specified railway station situated in the protected area, of cotton consigned from a railway station not situated in that area, unless such person holds a licence for the import of the cotton into that area.

Refusal to carry unlicensed cotton.

4. (1) Notwithstanding anything contained in the Indian Railways Act, IX of 1890, or any other law for the time being in force, the station master of any railway station or any other railway servant responsible for the booking of goods or parcels at that station may refuse to receive for carriage at, or to forward or allow to be carried on the railway from, that station any cotton consigned to a notified station, unless both stations are in the same protected area, or unless the consignor produces a certified copy of a licence for the import of the cotton into the protected area in which such notified station is situate.

(2) Every certified copy of a licence when so produced shall be attached to the invoice when the consignment is booked as goods and to the way-bill when the consignment is booked as a parcel, and shall accompany the consignment to its destination, and shall there be dealt with in the prescribed manner.

(3) Whereby or under any law in force in the territories of any State in India the import of cotton into any area, or the delivery of cotton at any railway station, situate in such State has been prohibited, the Governor-General in Council may, by notification in the Gazette of India, declare that the provisions of sub-section (1) shall apply in respect of all cotton consigned to any such station as if such area and such station were respectively a protected area and a notified station, and as if any licence granted under such law were a licence granted under this Act.

Procedure where cotton arrives at notified station.

5. (1) Where any cotton having been consigned to a notified station arrives at that station, the station master or other railway servant responsible for the receipt and delivery to the consignee of goods or parcels, as the case may be, at that station shall, unless both the notified station and the railway station from which the cotton has been consigned are situated in the same protected area, refuse to deliver the cotton until he is satisfied that the consignee holds a licence for the import of the cotton into the protected area in which such notified station is situated; and, if he is not so

satisfied, or if, within a reasonable time, the consignee or some person acting on his behalf does not appear in order to take delivery, shall return the cotton to the railway station from which it was consigned, together with an intimation that delivery of the cotton has been refused or has not been taken, as the case may be.

(2) Any station master or other railway servant receiving any cotton returned under sub-section (1) or returned with a like intimation from a railway station specified in a notification under sub-section (3) of section 4, shall cause to be served on the consignor, in any manner authorised by section 141 of the Indian Railways Act, IX of 1890, a notice stating that the cotton has been so returned and requiring the consignor to pay any rate, terminal or other charges due in respect of the carriage of the cotton to and from the railway station to which it was consigned, and such charges shall be deemed to be due from the consignor for all the purposes of section 55 of that Act.

Penalties.

6. Any person who, in contravention of the provisions of this Act, or of any notification or rule made hereunder, takes delivery of any cotton from a notified station or imports, or attempts to import, any cotton into a protected area, and any station master or other railway servant who, in contravention of the provisions of sub-section (1) of section 5, without reasonable excuse, the burden of proving which shall lie upon him, delivers any cotton to a consignee or other person, shall be liable to a fine not exceeding one thousand rupees, and upon any subsequent conviction to imprisonment which may extend to three months, or to fine which may extend to five thousand rupees, or to both.

Power to make rules.

7. (1) The Local Government may make rules to provide for any of the following matters, namely :—

(*a*) the prevention of the import of cotton into a protected area by road, river or sea save under, and in accordance with the conditions of, a licence ;

(*b*) the terms and conditions to be contained in licences and the authorities by which they may be granted; and

(*c*) the manner in which licences and certified copies thereof shall be dealt with on and after the delivery of the cotton to which they relate.

(2) Any such rules may provide that any contravention thereof or of the conditions of any licence, not otherwise made punishable by this Act, shall be punishable with fine which may extend to five hundred rupees.

Previous approval of Local Legislature to issue of notifications and rules.

8. No notification under section 3 or rule under section 7 shall be made by the Local Government of any Governor's Province, unless it has been laid in draft before the Legislative Council of the Province, and has been approved by a resolution of the Legislative Council, either with or without modification or addition, but upon such approval being given the notification or rule, as the case may be, may be issued in the form in which it has been so approved.

Protection for acts done under Act.

9. No suit or other legal proceeding shall be instituted against any person in respect of anything which is in good faith done or intended to be done under this Act.

STATEMENT OF OBJECTS AND REASONS.

The Indian Cotton Committee, which was appointed in 1917, brought to notice—

(1) that the practice of adulterating long staple cotton with short staple was very prevalent at the gins and press-houses in certain long staple areas, the object being to secure for the mixture the higher prices offered for long staple;

(2) that, owing to the consequent mixture of seed, there was considerable deterioration in the cultivation of many of the superior varieties of cotton;

(3) that soft cotton waste was also used for the purpose of adulteration with *kapas* (the natural floss); and

(4) that short staple cotton was frequently railed to a long staple area and re-booked thence, even without mixing as long staple cotton.

2. As instances of (1) and (2) the Committee quoted the imports of short staple cotton into the Broach tract, the result of which has been that Broach cotton has largely lost its former reputation. Other superior varieties of cotton are threatened with the same fate. The practice described under (4) above is facilitated by the trade custom whereby cotton is bought and sold on the name and reputation of the area where it purports to have been grown; *i.e.*, on the name of the railway station from which the bales are last booked.

3. These malpractices are exercising so serious and dangerous an influence on the industry as a whole, that the necessity of taking Governmental action has become a matter of immediate importance. The Bill provides a remedy by enabling Local Governments to prevent inferior cotton or cotton-waste, as defined, from being imported, except under licence, into areas which it is desired to protect.

The principal provisions of the Bill are as follows :—

(1) Local Governments are empowered, with the previous consent of the Provincial Legislature, to define the areas and to notify the stations which should be regarded as protected. Consignments of cotton are not allowed to any such notified station except from other notified stations in the same area.

(2) It is necessary to make certain exceptions to the prohibition in favour, for instance, of mill-owners within the area requiring extraneous cotton and of purchasers of cotton waste for industrial purposes. Local Governments are accordingly empowered to frame rules

for a licensing system and to appoint the authorities for the issue of licences.

(3) Station masters or other railway servants responsible for the delivery of goods or parcels are prohibited under penalties from delivering cotton improperly consigned to their stations.

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MEADE COTTON.

THE annual production of Sea Island cotton in the United States declined from 92,619 bales in 1917 to 6,916 bales in 1919, and it is feared that the growth of this variety will cease entirely within the next few years. This unfortunate situation is due to the ravages of the boll weevil, which has now invaded the Sea Island districts.

In order to provide for this contingency, the Bureau of Plant Industry of the U. S. Department of Agriculture has developed during 1912 and subsequent years a new variety of cotton to replace the Sea Island crop. This new cotton, which is known as "Meade," was produced from the "Blackseed," or "Black Rattler" variety. It matures two or three weeks earlier than Sea Island cotton, gives a great production of both lint and seed, bears larger bolls, and is therefore more easily picked.

Meade cotton is a long-stapled Upland form, producing, under favourable conditions, a fibre varying from $1\frac{7}{16}$ to $1\frac{3}{4}$ in. in length, with an average of $1\frac{5}{8}$ in., and of a fineness resembling that of Sea Island. In general, Meade cotton is so similar to Sea Island as to be almost indistinguishable from it. The seeds are nearly smooth, and the cotton can, therefore, be removed by an ordinary roller gin.

Spinning trials have been made with representative bales of Meade and Sea Island cotton grown during the seasons of 1916-17, 1918-19, and 1919-20 in order to determine their comparative spinning value, and an account of the results obtained is given in *Bull. No.* 946 (1921), *U. S. Department of Agriculture*, by W. R. Meadows, Cotton Technologist, and W. G. Blair, Assistant in Cotton

Testing. The results show that, on the average for the three seasons' cotton, the Meade cotton gave 3·5 per cent. more waste than the Sea Island in the various processes preparatory to spinning. Comparing the breaking strength of the Meade and Sea Island yarns for the three seasons, a difference of 17·2 lb. was found in favour of the Sea Island for 23's yarn, and 1·68 lb. for the 100's yarn. In the case of the cottons produced during the 1919-20 season, when adverse weather conditions prevailed, the breaking strength of Meade grown on sandy soil was equal to that of the Sea Island for the finer counts of yarn. [*Bulletin of the Imperial Institute,* XIX (3) of 1921.]

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A METAL PLANT BUCKET.

A DESCRIPTION has been received from one of the Ministry's Inspectors of a metal plant bucket intended for use in place of the ordinary flower pot. The inventor constantly noticed that certain plants appeared to give better results when grown in old pails and buckets. After experiments extending over several years he produced a bucket which has now been tested in the production of crops on a commercial basis for over six years with apparently satisfactory results. The bucket which is approximately 12 in. in height and 9 in. in diameter, is constructed of pure zinc and is practically indestructible. A special feature is a false or moveable bottom with a single hole underneath for drainage.

The chief reason for the superiority of the bucket over clay pots is that considerably less watering is required. This makes for the maintenance of a more equable root temperature especially during periods of rapid evaporation. The saving of labour in watering is also considerable. Its advantage over clay pots in the matter of breakage is obvious.

The disadvantage of the appliance is its cost. It is patented and at the moment is manufactured in a spasmodic way without special plant at a cost of 2*s.* 10*d.* each. The patentee has found, however, that while it is extremely desirable to cheapen the bucket, the present cost is not prohibitive for the purpose for which it is used.

One of the most striking purposes for which the plant bucket is employed at Hassocks is the cultivation of high quality dessert pears under glass. The method followed is very simple. Cordon pear trees of choice dessert varieties are propagated on the premises and permitted to attain a bearing age outside. They are then lifted, planted in the plant bucket and brought into the houses. At the conclusion of the fruiting period the trees are taken outside again, the culture, once the trees are in the buckets, being that usually accorded to orchard house trees. The writer inspected a house of pears grown in this manner and was considerably impressed with their appearance. A crop of from one dozen to two dozen fruits is allowed to each tree and these are matured without any trouble. No artificial heat is employed and pests are not severe, the few caterpillars which appear in the spring being removed by hand-picking.

Tomatoes are also successfully grown in the bucket and this crop affords a satisfactory basis for comparison with flower pot culture. In every case the buckets give much better results, the plants being healthier generally and yielding heavier crops of fruit. The tomato plants are obviously supplied with a steadier supply of water in the buckets, a factor in the development of fruit which all growers will appreciate.

Chrysanthemums also exhibit a marked difference in the general growth and quality of the bloom when grown in the bucket as compared with pots. [*Jour. Min. Agri.*, XXIX, 1.]

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THE RIPENING OF GRAPE-FRUIT.

THE results of investigations carried out in connection with the ripening of grape-fruit are given in the *Journal of Agricultural Research* (XXII, 5). They show that in warm storage the percentage of acid calculated to the net weight of the pulp increases markedly in two months' storage. There is evidence that this increase is not due entirely to loss of water from the pulp, but that there is an increase in the amount of acid present. There is evidence indicating that there may be a slight decrease in the sugar content in warm storage.

In cold storage there is a decrease in the acidity very marked after four months in storage, while there is little change in the amount of total sugars present. A possible explanation of this difference in the behaviour of the sugars and acids in warm and cold storage was pointed out. This phase of the problem deserves further attention. The investigations on the changes in the fruit during development on the tree showed that the total sugar content increased while the acidity decreased, the increase in sugar content being very marked.

Fruit on the tree increases in palatability and food value. There is, of course, always danger that the seeds will sprout in the varieties containing seeds if the fruit remains on the tree too long. There is also danger that the fruit will drop or be shaken from the tree by high winds.

It is of interest to note that the behaviour of the acids and sugars during growth and in cold storage is similar to the behaviour of these constituents of some of the deciduous fruits—that is, it is apparently possible to remove the fruit from the tree after it is well along toward maturity and to ripen it in storage. The result will be an apparently sweeter fruit, due to loss of acidity and a reduced bitterness, the naringin or bitter principle breaking down in storage. A period in cold storage then renders the fruit more palatable. From the experiments detailed above it seems probable that the pitting of grape-fruit can be controlled by curing at 70° F. before they are placed in cold storage. Investigations are in progress at the present time on this last-mentioned phase of the work. [*The West India Committee Circular*, 607.]

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* *

A SIMPLE METHOD OF OBTAINING THE NUTRITIVE RATIO OF MIXED RATIONS.

MR. E. T. HALNAN gives in the *Journal of the Ministry of Agriculture* (XXVIII, 10) the following method of obtaining the nutritive ratio of mixed rations:—Ascertain the amount of digestible protein present in each ingredient in the ration and multiply this by the nutritive ratio to get the carbohydrate equivalent. Do this for each ingredient in turn, add the digestible

protein figures together and also the figures obtained by multiplying by the nutritive ratio, divide this second figure by the first and this will give the nutritive ratio of the ration. A concrete example will illustrate the method :—

Ration			Dig. crude protein.		Carbohydrate equiv.
4 lb.	Linseed cake ..	contains	$(4 \times 0{\cdot}253) = 1{\cdot}01$	and	$(1{\cdot}01 \times 2) = 2{\cdot}02$
50 lb.	Mangolds ..	,,	$(50 \times 0{\cdot}007) = 0{\cdot}35$	,,	$(0{\cdot}35 \times 13) = 4{\cdot}55$
10 lb.	Meadow hay ..	,,	$(10 \times 0{\cdot}054) = 0{\cdot}54$	,,	$(0{\cdot}54 \times 8) = 4{\cdot}32$
			$1{\cdot}90$		$10{\cdot}89$

$$\text{Nutritive ratio of ration} = \frac{10{\cdot}89}{1{\cdot}9} = 1 : 5{\cdot}6$$

Any other ration may be worked out in a similar manner.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WE deeply regret to have to record the death of Mr. Alec A. Henry, Deputy Director of Agriculture under training, Burma, which occurred at Maymyo on 18th April, 1922. The late Mr. Henry joined the Indian Agricultural Service in December 1921.

HIS MAJESTY THE KING-EMPEROR'S BIRTHDAY HONOURS LIST contains the following names which will be of interest to the Agricultural Department :—

I.S.O. MR. C. H. MARTIN, Registrar, Department of Revenue and Agriculture, Government of India.

Khan Sahib. MOULVI FATEH-UD-DIN, B.A., M.R.A.S., Assistant Director of Agriculture, Punjab.

Rai Sahib. CHAUDHRI HARI RAM SINGH, Agricultural Inspector, Muzaffarnagar District, United Provinces.

Rao Sahib. MR. GOVIND DATTATRYA KHANDKAR, Deputy Superintendent, Civil Veterinary Department, Berar, Central Provinces.

* * *

MR. M. J. BRETT, M.R.C.V.S., has been appointed to the Indian Civil Veterinary Department and posted to the Imperial Bacteriological Laboratory, Muktesar.

* * *

MR. J. B. KNIGHT, M.Sc., Offg. Principal and Professor of Agriculture. Agricultural College, Poona, has been granted combined leave for 1 year 11 months and 8 days.

Dr. W. Burns, Economic Botanist, Bombay, has been appointed to act as Principal of the Agricultural College, Poona, *vice* Mr. Knight on leave.

***

Mr. B. S. Patel, B. Ag., has been appointed to act as Professor of Agriculture in addition to his present duties as Associate Professor of Animal Husbandry and Dairying, Agricultural College, Poona.

***

Mr. P. C. Patil, L. Ag., Deputy Director of Agriculture, Bombay, has been allowed by His Majesty's Secretary of State for India an extension of study leave for two months and twenty days.

***

Mr. F. R. Parnell, B.A., Government Economic Botanist, Madras, has been appointed Principal, Agricultural College, Coimbatore, in addition to his own duties.

***

Mr. D. Balakrishna Murti Garu, Deputy Director of Agriculture (on probation), II Circle, Madras, has been appointed to act as Professor of Agriculture, Agricultural College, Coimbatore.

***

Mr. K. Gopalkrishna Raju has been appointed to act as Deputy Director of Agriculture, II Circle, Madras Presidency, *vice* Mr. D. Balakrishna Murti Garu.

***

Mr. K. T. Alwa has been appointed to act as Deputy Director of Agriculture, VII Circle, Madras Presidency, *vice* Mr. Govinda Kidavu granted leave.

***

Mr. N. S. Kulandaswami Pillai has been appointed to act as Deputy Director of Agriculture, V Circle, Madras Presidency, in an existing vacancy.

Mr. C. Narayan Ayyar has been appointed to act as Deputy Director of Agriculture, VIII Circle, Madras Presidency, *vice* Mr. Sampson on other duty.

***

Mr. T. J. Hurley, M.R.C.V.S., has been appointed to the Indian Civil Veterinary Department and posted to Madras.

***

Mr. P. T. Saunders, O.B.E., M.R.C.V.S., Professor of Surgery, Madras Veterinary College, has been appointed Superintendent, Civil Veterinary Department, I Division, Madras Presidency, *vice* Mr. McElligott resigned.

***

Mr. G. T. D'Silva, Assistant Principal, Madras Veterinary College, has been appointed to act as Professor of Surgery at the College, *vice* Mr. Saunders.

***

Mr. V. Krishnamurti Ayyar, First Lecturer at the Veterinary College, Madras, has been appointed to act as Professor of Pathology and Bacteriology, *vice* Mr. Cattell.

***

Mr. P. J. Kerr, M.R.C.V.S., Offg. Principal, Bengal Veterinary College, has been appointed to act as Superintendent, Civil Veterinary Department, and Veterinary Adviser to the Government of Bengal, from 18th April, 1922.

***

Mr. A. D. MacGregor, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal, has been appointed to act as Principal, Bengal Veterinary College, *vice* Mr. Kerr, from 18th April, 1922.

***

Mr. R. T. Davis, M.R.C.V.S., has been appointed to act as Second Imperial Officer, Bengal Veterinary College.

Dr. H. M. Leake has been appointed a member of the United Provinces Legislative Council, *vice* Mr. G. Clarke resigned.

***

Mr. G. C. Sherrard, B.A., Deputy Director of Agriculture, Patna Circle, Bihar and Orissa, has been granted leave on average pay from 1st May, 1922. Mr. J. Robinson officiating.

***

Mr. P. S. Woolf has been appointed Cattle Breeding Expert to the Government of Punjab in the Department of Agriculture.

***

Mr. H. R. Stewart, D.I.C., has been appointed Professor of Agriculture, Agricultural College, Lyallpur.

***

The five months' leave granted to Sirdar Darshan Singh Deputy Director of Agriculture, Hansi, Punjab, has been extended by 3 months.

***

Mr. R. Branford, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar, has been granted combined leave for 8 months. Mr. E. Sewell, M.C., M.R.C.V.S., officiating.

***

Mr. K. J. S. Dowland, M.R.C.V.S., Professor of Parasitology, Punjab Veterinary College, has been appointed Professor of Hygiene, in addition to his duties, relieving Mr. E. Sewell.

***

Mr. T. J. Egan, who has been appointed to the Indian Civil Veterinary Department, has been posted to the Government Cattle Farm, Hissar, for training as Assistant Superintendent of the farm.

MR. R. WATSON, Deputy Director of Agriculture, Burma, has been transferred from Mandalay and posted to special duty with headquarters at Hmawbi in the Insein District.

***

MAUNG BA GYAW, Agricultural Engineer, Burma, has been granted leave on average pay for three months.

Reviews

Aeration and Air-content, the rôle of oxygen in root activity.—By FREDERIC E. CLEMENTS. Publication No. 315, Carnegie Institution of Washington, 1921.

ALTHOUGH an enormous amount of work has been done on respiration and particularly on the respiration of roots, it must be confessed that till recent years the significance of the soil aeration factor in growth problems has either been ignored altogether or treated with little consideration. If a number of the recent text-books dealing with botany, forestry and agriculture are examined, it will be found that soil aeration is not even mentioned by the majority and that with few exceptions very little attention is given to this subject. A change, however, is now taking place. The careful studies of the rôle of oxygen and carbon dioxide in the root development and growth of the vegetation found in swamps and bogs in the United States and particularly the investigations of the so-called bog xerophytes have shown the air-content of the soil to be an ecological factor of primary importance. In India, the investigations carried out at Dehra Dun, Pusa, Quetta and Coimbatore have materially assisted in establishing soil aeration as an important factor in the future development of forestry and agriculture.

One of the consequences of the detailed investigation of the part played by oxygen and carbon dioxide in the soil which is now taking place at several centres in the United States is the monograph under review. In this Dr. Clements has attempted a critical digest of past work in so far as it relates to transpiration, growth and movement or bears on bog toxins, acid soils and toxic exudates. In addition there is a complete account of the development of

views on soil toxins which has been written with a view of showing what is the existing opinion on this question and what are the precise points which need further investigation. These matters, including the bibliography, are dealt with in 183 pages of print. The first section is concerned with respiration and the need of oxygen, the second with bog xerophytes and acid soils and the last with toxic exudates and soil toxins. While the whole monograph should be carefully studied by agricultural investigators interested in soil problems, certain sections bear directly on the growth of crops and are of particular interest to the student of agricultural science. One of these is that dealing with the air content of the soil from which it is clear that the percentage of carbon dioxide, especially in manured and water-logged soil, often reaches a figure which makes it certain that injury from this gas is much more frequent than is commonly supposed and also indicates that it must be taken into account in all cases of toxic action. The influence of algæ and water-plants on oxygen content touches a subject of great interest to India, namely, the part played by algæ in rice cultivation. Starting from the work of Brizi in 1906 when the significance of algæ in the aeration of higher plants first became clear, there follows a summary of the investigations of Chambers, of Harrison and Aiyer at Coimbatore, of Bergmann, Esmarch, Robbins, Moore and Karrer down to the very recent investigation of Miss Bristol at Rothamsted. It seems certain from Miss Bristol's work that the presence of algæ in soils sufficiently moist to permit of their growth must increase the aeration and prevent the harmful action of carbon dioxide in a similar manner as in rice fields. Algal films are common in the surface soil in Bihar during the rains and are probably very widely distributed in India.

A large amount of the Indian work on soil aeration is dealt with in connection with the ecological significance of soil aeration which is summed up as follows :—

"The results of field studies of aeration are in complete agreement with those obtained from physiological investigations as to the basic importance of oxygen for root activity and the injury wrought by the accumulation of carbon dioxide. The detailed

significance of the lack of oxygen and the abundance of carbon dioxide as ecological factors is discussed in connection with bog xerophytes and soil toxins. Here it will suffice to point out that field research has approached the problem of an oxygen deficit from four different angles, and that the results and conclusions are all in essential accord. The agricultural approach has been made by Sorauer, Dehérain, Wollny, Brizi, Ehrenberg, Balls, Harrison and Aiyer, Howard and Howard, Main. and Allan. and that of forestry by Vonhausen Böhm. Mangin, Hesselmann, Bernbeck. Hole, Hole and Singh. and Coventry. Pathological considerations have entered into many of the studies, but they have received especial attention at the hands of Sorauer, Hartig. Mangin, Howard, and Graves, while the ecological outlook has been represented by Warming and Clements."

In this section considerable space has been devoted to the water-saving experiments on wheat conducted at Quetta, Mirpurkhas, Gangapur and Shahjahanpur.

Perhaps the most interesting chapter of the monograph is the concluding article on toxic exudates and soil toxins in which the earlier papers and the Woburn results are considered in detail as well as those which have appeared as a result of the publication of Pickering's views. Dr. Clements concludes his summary of the soil toxin question in its relation to soil aeration in the following paragraph :—

" Soil toxins are probably to be definitely related to deficient aeration and to anaerobic conditions, as has been indicated by Schreiner, Hall, Russell, and others. This is also shown by the fact that they are readily oxidized, and soon disappear under proper tillage. Hence, they appear to be due to essentially the same conditions and processes as obtain in bogs, the relationship being especially well exhibited by muck soils. In both, the primary causes of toxicity are the direct lack of oxygen and its indirect effect in permitting the accumulation of carbon dioxide in harmful amounts and in producing injurious organic acids and other compounds. In many cases probably the first two alone are concerned, but in sour soils and muck soils at least, all of them must

have a part, though the lack of oxygen plays the primary rôle. Since carbonic and other acids are the products of respiration under such conditions, a considerable part of soil acidity may be ascribed to them, though it must be recognized that toxic effects may arise from acidity otherwise produced, as shown in the preceding section. In conclusion, the present facts appear to warrant the statement that organic toxins are excreted by roots or produced in soils only as a consequence of the anaerobic respiration of plant roots and of micro-organisms, and that inorganic toxins may arise as a result of chemical processes or of adsorption." [A. H.]

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Botany with Agricultural Applications.—By J. N. MARTIN. Second edition revised, pp. 604. (London : Chapman & Hall.) Price, 21*s*.

UNLIKE most of the text-books designed for use in Agricultural Colleges, this work deals with the life-history of a flowering plant and with the other groups met with in the vegetable kingdom in a thoroughly scientific manner. No attempt is made to gloss over the more difficult portions of the science. Written for American students, the illustrations are naturally taken from plants growing in the United States. Many of these, however, are distinctly original and should prove both stimulating and useful to teachers in India. The only criticism that could be advanced against the book is that it covers too wide a ground and deals with such subjects as ecology, variation, heredity, evolution and plant breeding in too small a compass, these matters being disposed of in some 82 pages. An obvious improvement in future editions would be to discuss these important divisions of the subject in greater detail in a second volume. In spite of such shortcomings, the volume is an important addition to the literature of the subject and should find a place in the libraries of the Indian agricultural colleges. [A. H.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

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1. British Insect Life: A Popular Introduction to Entomology, by E. Step. Pp. 264. (London: T. Werner Laurie.) Price 10*s*. 6*d*.

2. Farm Buildings and Building Construction in South Africa: A Text-book for Farmers, Agricultural Students, Teachers, etc. Second Edition. Pp. xxiv+349. (London: Longmans Green & Co.) Price 25*s*.

3. Crops and Tillage, by J. C. Newsham. (London: Methuen & Co.) Price 6*s*.

4. Agricultural and Industrial Bacteriology, by R. E. Buchanan. Pp. 486. (London: D. Appleton & Co.) Price 15*s*. net.

5. Breeding Crop Plants, by H. K. Hayes and R. J. Garber. Pp. 328. (New York and London: McGraw-Hill Book Co., Inc.) Price 21*s*.

6. Farming Costs, by C. S. Orwin. (Oxford University Press.) Price 8*s*. 6*d*. net.

7. Agricultural Co-operation in England and Wales, by W. H. Warman. With Preface by Leslie Scott. Pp. 204. (London: Williams and Norgate.) Price 5*s*.

8. An Introduction to Cytology, by Lester W. Sharp. Pp. 452 and 159 Illustrations. (New York: McGraw-Hill Book Co., Inc.).

9. Agricultural Geology, by Frederick V. Emerson. Pp. 319. (London: Chapman and Hall.) Price 16*s*. 6*d*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. New and Rare Indian Odonata in the Pusa Collection ; Further Notes on Rhinocypha Larvæ, by Major F. C. Fraser, I.M.S. (Entomological Series. Vol. VII, Nos. 7 and 8.) Price R. 1-4 or 1*s*. 9*d*.

Bulletins.

2. *Helminthosporium* Disease of Rice, by S. Sunderaraman, M.A. (Bulletin No. 128.) Price As. 9.
3. Feeding Experiments at Government Cattle Farm, Hissar, by R. Branford, M.R.C.V.S., and E. Sewell, M.C., M.R.C.V.S. (Bulletin No. 130.) Price As. 3.

Original Articles

SOME COMMON INDIAN BIRDS.

No. 17. THE PIED MYNAH (*STURNOPASTOR CONTRA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

ALTHOUGH almost as familiar a bird in North Eastern India as the Common Mynah, the Pied Mynah has a much more restricted distribution, being found only east of a line drawn from Amballa to Hyderabad, in the Deccan, and Masulipatam, ranging to the extreme east of Assam. Where it occurs, it is common and conspicuous, both by its strongly contrasting colours of black and white and by its habit of hunting about over grass in the open, often in small flocks, and there is little chance of mistaking any other bird for this one. Our Plate gives a good idea of its colouration, so that there is no need to describe this here.

Like its commoner relative, the Pied Mynah is a frequent attendant on cattle, picking up the various insects disturbed as the latter graze. It also hunts, almost always in small parties, over any open grassy spaces, catching and eating grasshoppers, crickets, caterpillars, ants and other insects and I have seen one extract and eat a large earthworm. Mr. C. W. Mason examined the stomach-contents of fourteen birds at Pusa and found that, of thirty-nine insects taken, one was beneficial, twenty-five injurious and thirteen

of neutral value, and remarks that, on the whole, the Pied Mynah is decidedly more vegetarian in its diet than the Common Mynah. "When any *Ficus* fruit is ripe or a cereal crop, such as maize, the birds flock to these and at times will be found to feed on little else. They seem even more partial to *Ficus* fruit than the Common Mynah. Some considerable damage is done at times to the various common cereal crops—maize, sorghum and paddy especially. Its insect-food is much the same as that of the Common Mynah, consisting as far as one can see in the field very largely of grasshoppers, small moths, etc." It may, however, be added, in justice to this bird, that nearly all of Mr. Mason's records were obtained in this case between February and June, when relatively little insect-food is available; I am inclined to think that a longer series of records, better spread over the year, would show that the Pied Mynah is rather more largely insectivorous. Of course, like all similar birds with a mixed diet, it does levy toll on ripe grain, and the conspicuous colours of this bird rather tend to accentuate its presence in grain-fields, but against this must be placed the fact that it is continuously at work throughout the year in reducing the number of insects which, if unchecked, would undoubtedly do far more damage to the crops than is done by the birds. Further, it must be remembered that examination of the bird's stomachs only reveals their contents and does not indicate how the food has been acquired; in many cases, even when these birds are found feeding on cereal crops, the grain eaten is largely picked up off the ground and is almost always intermixed with a considerable proportion of insect-food. In the case of one bird examined at Nagpur, Mr. D'Abreu found it to contain four earwigs, two mole-crickets, two caterpillars, a bug, a batch of forty-seven insect eggs, and one red mite—which seems quite a useful effort for one meal; and it must be remembered that such a quantity is probably only a fifth or sixth of the total quantity eaten by one bird in the course of a single day. The occasional levy of a little grain, when it is abundant and when insect-food is scarce, as is usually the case during the harvest season, must not be begrudged to birds, such as Mynahs, which on the whole are decidedly beneficial.

Cunningham, whose remarks on other birds we have frequently quoted in preceding articles, does not seem very kind to the Pied Mynah and writes :- "They are not nearly such attractive birds as the Common Mynas ; for their colouring is coarsely laid on in a way that recalls that of certain of the ornithological inmates of a Noah's ark ; their heads have a debased look, and they have neither the pleasant notes nor the alluringly familiar ways of their relatives. Like the latter, and very often in company with them, they spend their nights, save during the nesting season, in huge mobs, which, if possible, are even more vociferous than those of mynas. At sundown the din proceeding from such assemblies is often so overpowering as to render even the concerts of the crows or of the great autumnal crickets temporarily inaudible. Although roosting in and haunting gardens, they never show any desire to enter houses." In Bihar, this bird seems to be locally migratory ; at all events, it seems to occur in large numbers at some times and at other times none are noticed during quite a considerable period.

The breeding season of the Pied Mynah is from May to August but most birds lay in June and July. At the time of writing (4th June) there is a nest in a *Dalbergia* tree alongside my bungalow and this apparently contains young birds, as the parents are bringing in food, principally caterpillars apparently, but they are shy and it is not always easy to see what they do bring. The nest is situated in the fork, near the extremity of a bough, some twenty feet from the ground, and is a large untidy mass of twigs with a few strips of rags attached to the underside, relatively huge for the size of the bird, being about two feet in diameter, but by no means unduly conspicuous amongst the leafy foliage. This is quite a typical nest, these being built as a rule of straw, grass, twigs, roots and rags, with a deep cavity lined usually with quantities of feathers. Very rarely the nest may be placed in the cavity afforded by a hollow tree-trunk. Five eggs are laid as a rule, sometimes four, and occasionally as many as six. The egg is typically a moderately broad oval, considerably pointed towards one end, but sometimes pear-shaped, pale to sky-blue, sometimes tinged with green, unspotted and brilliantly glossy, in size about 28 millimetres long by

20 broad. The young, as in the case of most birds with a mixed diet, are fed wholly on insects which are brought in by the parents.

The Pied Mynah is protected under the Wild Birds' Protection Act, in the United Provinces, Bengal and Assam. Oates gives the vernacular names under which it is known as *Ablak maina* in Hindi, *Ablaka gosalik* and *Guialeggra* in Bengali, and *Venda gorinka* in Telugu.

COIMBATORE SUGARCANE SEEDLINGS IN THE UNITED PROVINCES.

BY

G. CLARKE, F.I.C.,

KHAN SAHIB MOHD. NAIB HUSAIN,

AND

S. C. BANERJEE, F.C.S.,

Agricultural Department, United Provinces.

I. INTRODUCTION.

CLIMATIC conditions in the United Provinces demand a special type of sugarcane. The period of active growth is short, and is confined to the four months, June–September, during which monsoon conditions prevail.

The following characters are of *primary* importance :—

(1) Strong root system,

(2) Early and vigorous growth,

(3) Yield of cane,

(4) Percentage of juice,

(5) Sucrose content,

(6) Early ripening,

in addition, resistance to disease and erect habit are also of importance.

Three methods of obtaining suitable canes for various types of cultivation practised in the United Provinces are being followed at Shahjahanpur :—

(1) The investigation of Coimbatore seedlings.

(2) The importation of canes from other countries.

(3) The isolation of pure lines of indigenous canes.

This is in practice the examination of new types of cane produced by cross-fertilization, and the simple selection of the best types already existing. All three methods have given definite results. The first method presents great possibilities of maintaining a regular supply of new and vigorous canes of better quality than those at present grown. This is essential in order to establish improved sugarcane cultivation, and to increase permanently the production of sugar and *gur* (raw, unrefined sugar).

The production of seedling canes for distribution in the sugarcane tracts of North India was commenced at Coimbatore in 1912. The first series of selected seedlings was received at Shahjahanpur in 1918, and from then onwards seedlings have been received each year, the total up to the time of writing being thirty-seven.

The numbers under investigation are shown below :—

Year	Seedling canes received at sowing time	No.
1918	Co 201 — Co 216	16
1919	Co 218 — Co 221 ; Co 223	5
1920	Co 224 — Co 227	4
1921	Co 229, Co 234 — Co 238	6
1922	Co 239 — Co 244	6

The work carried out at Coimbatore alone will not solve the problem of producing canes suitable for the United Provinces, unless it is supplemented by systematic investigation of the seedling canes in the environment in which, if successful, they will ultimately be grown. Considerable trouble was, therefore, taken to devise a method for the critical examination of the seedlings received from Coimbatore.

Method of examining seedling canes.

The manner in which the examination of the seedling canes is carried out is given below :—

The setts received at sowing time (usually six setts of each seedling) are planted in trenches in a field, in which the main crop of cane is grown. They are planted in the middle of the field, and treated in exactly the same way as the field crop. This method is quite satisfactory, and a special nursery is not required. During the first year preliminary observations are made of general agricultural characters, and at the close of the season the juice is analysed. A small amount of cane only is available for analysis, but the results are of some value. No selection has been hitherto attempted during the first year. As more experience is gained it seems probable, however, that many obviously unsuitable seedlings can be eliminated at this stage.

In the second year all seedlings are planted. As a rule, there is sufficient seed of 1/60 acre (one row in the Shahjahanpur fields). Observations are made of agricultural characters, such as germinating capacity, vigour, habit, and freedom from disease. Ripeness tests are commenced in early November. This is the period at which the earliest ripening indigenous cane is ready for crushing. Ripeness tests are usually made at intervals of a month. Three tests—one in November, one in December, and one in January—are sufficient. During the second year those seedlings which are obviously unsuitable for the conditions of soil and climate in the United Provinces are eliminated. Poor growth and habit, liability to attack of smut (*Ustilago sacchari*), and inability to withstand the low temperatures of the months of December and January are the usual causes of rejection at this stage.

In the series Co 201—Co 216 the selection in the second year was not very rigid. Several seedlings were carried on to a field scale, which, later experience has shown, could have been safely rejected.

As a result of the second year's work only those seedlings, which have a healthy and vigorous growth, and which show promise

of a good yield per acre, are normally carried on to a field scale. Ripeness tests have given an indication of the value of a seedling as a sugar producer, but a final opinion on this point, except in abnormal canes, is not formed, until the selected seedlings have been grown on a field scale. In selecting field crops the agricultural characters are of primary importance. Whatever may be the sugar content of a cane, or whatever other desirable properties it may possess from the factory point of view, if it does not grow easily, give a good crop, and mature properly under the conditions normally occurring, it is obviously of no value.

The percentage of sucrose, purity of juice, and other data obtained by analysis are of use only when considered in connection with the agricultural characters of the seedling ; moreover, strict comparison is only possible when the growth is perfectly normal, and on a scale sufficiently large to smooth out the unavoidable errors. Then sucrose content and other data are *relatively* constant characters, and of the greatest use in ultimately deciding on the value of a seedling.

In the third year 1/6 acre is planted and 1/10 acre is used for the outturn tests. This yields from 70 to 100 maunds* of cane, the whole of which is crushed. The milling qualities are noted, the mixed juice is analysed, as well as the bagasse. The juice is finally made into *rab* which is also analysed, and its appearance, colour and market value noted. Ripeness tests are usually continued in the third year as in previous years.

As a result of the observations made in the third year reliable information is obtained on the following points :—

(1) Yield of cane per acre.
(2) Time of ripening.
(3) Juice expressed per 100 parts cane.
(4) Sucrose per 100 parts juice.
(5) Purity of juice.
(6) Sucrose per 100 parts cane.
(7) Quality of *rab*.

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* 1 maund = 82·3 lb.

At the end of the third year's work it is possible to make a fairly rigorous selection.

In the fourth year the field experiments are continued, and at the end of the season a final selection is made of those seedlings which are to be carried on to a large scale in the fifth year for further trial and for the production of setts for distribution.

It will thus be seen that five years are required to complete the systematic testing of a seedling under experiment station conditions. It is possible that one of exceptional merit might be distributed at an earlier stage to circle farms in order to establish a local supply of setts before the final tests are completed, but it would be unwise to distribute to cultivators until the quality of the product (*rab* and *gur*) is known. It must be remembered that the final test of the experiment station results is made by the cultivator on his own field, and that a final judgment cannot be pronounced until the selected seedlings have been tried under the various local conditions prevailing.

II. Results of examination of Coimbatore seedling canes.

(*a*) *Series Co* 201—*Co* 216.

As already stated, the first series of seedlings was received at Shahjahanpur in February 1918.

An account of the origin of these seedlings has been published[1] and for reference is given below :—

Co 201 Pansahi seedling.
Co 202 Chittan seedling.
Co 203 Saretha seedling.
Co 204 Chittan seedling.
Co 205 Vellai × *Saccharum spontaneum* (bagged cross).
Co 206 Ashy Mauritius seedling.
Co 207 J 213 × Saretha (unbagged cross).
Co 208 J 213 seedling.
Co 209 Khelia seedling.

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[1] Venkatraman, T. S. *Bull.* 94, *Agri. Res. Inst., Pusa*, 1920.

Co 210 J 213 seedling.

Co 211 Green sport of Striped Mauritius × Saretha.

Co 212 J 213 × M 2 (unbagged cross).

Co 213 J 213 × Kansar (unbagged cross).

Co 214 Striped Mauritius × (Saretha × *Saccharum spontaneum*).

Co 215 Striped Mauritius × (Saretha × *Saccharum spontaneum*).

Co 216 Green sport of Striped Mauritius × Saretha.

The value attached to this account of the origin of the seedlings is fully discussed in the bulletin referred to. The first named cane in each case is the one from the arrows of which the seed was obtained. but as the source of the pollen could not be definitely ascertained. the parentage must be uncertain.

As a result of observations based on agricultural characters made in 1918-19 and 1919-20, the following seedlings were definitely rejected during the second year for the reasons noted against each.

Co 203 Poor growth. Smut appeared on 1st November, 1919, and all shoots were badly affected at the end of the season.

Co 209 Poor growth. Smut appeared early in the season (1st June, 1919), and almost the whole was destroyed by harvest.

Co 211 Miserable growth throughout, but not attacked by smut.

The following seedlings exhibited characters, during the first and second seasons, which made it probable that they would be unsuccessful in the United Provinces. They were continued however to a third year (but not on a field scale) in order to confirm this opinion.

Co 201 Very bad habit. Lodged early in each season, when earthed up, and in years of moderate rainfall, when all other canes were erect. It gave heavy yields of poor quality cane.

Co 202 Showed the same characters as Co 201.

Co 206 The upper leaves near the growth point began to wither at the end of the rains. This was noticed in September 1919-20, as soon as the plots were sufficient in size to enable the massed habit to be observed. It occurred again in 1920-21 and 1921-22. Duplicate plots in the same year gave the same result. It is undoubtedly a permanent condition. The cause has not been ascertained. The juice contained an abnormally high percentage of ash.

Co 207 Very poor growth throughout. Sucrose high as is usual in canes of stunted growth. Attacked by smut.

Co 208 Leaf withering near the growth point in the same manner as Co 206, but later in the season, *viz.*, in December and January. It is impossible to say if this is due to the same cause, or to the low temperatures which prevail in December and January.

Co 215 Slight leaf withering of upper leaves near the growth point late in the season.

Some shoots affected with smut were observed in Co 212 and Co 213 varieties. Venkatraman noted one shoot of Co 214 affected by smut.[1]

At the end of the second season (1919-20) three seedlings, *viz.*, Co 203, Co 209 and Co 211, were definitely rejected. Six, *viz.*, Co 201, Co 202, Co 206, Co 207, Co 208 and Co 215, showed characters which made it probable that they would be of no value in the United Provinces. Seven seedlings, *viz.*, Co 204, Co 205, Co 210, Co 212, Co 213, Co 214 and Co 216, showed vigorous and early growth, and erect habit. They possessed the agricultural characters necessary for a successful cane in the United Provinces, and the problem was therefore narrowed down to selecting those which possessed good sugar producing capacity. The above

[1] *Bull.* 94, *Agri. Res. Inst., Pusa,* 1920, p. 13.

seedlings were therefore selected for trial on a field scale. although some of them, as previously stated, were not immune to smut.

The observations made in the third year confirmed the opinion arrived at regarding the doubtful seedlings referred to in the preceding paragraph. These were definitely rejected, but Co 208 and Co 215, which showed certain useful qualities, were retained for further observation of the effect of low temperatures.

Many of the seedlings rejected on account of indifferent agricultural characters had also a very low percentage of sucrose in the juice, and did not mature properly. On the other hand, some seedlings of poor growth contained a high amount of sucrose. This frequently accompanies abnormal or pathological conditions in a sugarcane. The data[1] obtained in the ripeness tests of the rejected seedlings are given in Table I.

The interesting points of the third and fourth years' work are the outturn, crushing, and *rab* making tests carried out with the seedlings selected for further field observations. The seasons 1920-21 and 1921-22 were good, and an excellent crop was obtained. The selected Coimbatore seedlings were remarkable for vigour, early growth, and erect habit. The selection had resulted in a series of seedlings well suited, as far as agricultural characters were concerned, to the conditions at Shahjahanpur. Two seedlings, Co 204 and Co 205, are thin canes resembling indigenous varieties, and were grown on the flat in rows of two feet apart. The remainder, Co 210, Co 212, Co 213, Co 214 and Co 216, are medium canes, and were grown in trenches four feet apart.

The results of ripeness tests for the period 1918—1922 and the outturn tests for 1920-21 and 1921-22 are given in Tables II and III, and for the purpose of comparison the results obtained with two standard varieties selected at Shahjahanpur (S 48 and A 42) are also given. S 48 is a medium cane, and A 42 is a pure culture isolated from a mixture of indigenous canes.

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[1] Sucrose and glucose were estimated throughout by the methods described in *Bull.* 13, *Agri. Res. Inst., Pusa*, 1908, p. 13.

TABLE I.

Ripeness tests of Coimbatore seedlings rejected, 1920–1921.

	1918–1919		1919–1920						1920–1921					
	10th Jan., 1919		4th Nov., 1919		4th Dec., 1919		20th Jan., 1920		19th Nov., 1920		18th Dec., 1920		28th Jan., 1921	
	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
Co 201 ..	9·9	2·1	9·2	2·8	11·6	2·4	12·7	1·7	10·6	2·5	11·9	1·9	12·3	1·6
Co 202 ..	10·2	2·3	8·4	3·3	10·5	2·9	10·4	2·4	11·2	2·6	12·3	2·0	12·8	1·7
Co 206 ..	9·7	2·0	9·0	2·9	9·0	3·2	11·3	2·1	11·2	1·9	12·9	2·1	13·8	1·3
Co 207 ..	12·5	0·9	12·2	1·9	15·1	0·9	15·4	0·3	14·5	0·6	15·6	0·3	17·6	0·1
Co 208 ..	11·7	1·8	8·9	3·3	11·0	2·6	13·1	2·2	11·4	2·4	13·5	1·4	15·5	1·1
Co 215 ..	11·9	1·7	..	..	11·6	2·0	13·7	1·1	14·1	1·4	15·3	0·9	16·0	0·7

The figures give parts of sucrose and glucose per 100 parts juice.

TABLE II.

Ripeness tests of Coimbatore seedlings selected for field trial.

	1918–1919		1919–1920						1920–1921						1921–1922	
	10th Jan., 1919		4th Nov., 1919		4th Dec., 1919		20th Jan., 1920		18th Nov., 1920		18th Dec., 1920		12th Jan., 1921*		24th Dec., 1921*	
	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
Co 204	11·5	2·2	8·3	3·9	9·9	3·1	11·5	2·3	11·8	2·4	12·1	1·8	12·1	2·3	9·4	2·9
Co 205	12·3	2·3	7·5	3·9	10·1	3·2	11·5	2·5	10·5	2·6	11·9	2·5	12·0	2·9	11·4	2·1
A 42	18·2	0·2	14·1	1·3	15·5	1·5	15·9	1·8	14·8	1·2	16·0	1·2	16·2	1·2	16·0	0·7
Co 210	8·2	2·3	9·1	2·8	11·4	2·5	14·0	1·1	10·1	2·3	12·4	1·8	12·0	1·7	12·7	1·6
Co 212	9·3	2·4	..	..	12·8	1·5	14·0	0·6	11·2	2·0	12·9	1·8	13·9	1·1	12·9	1·5
Co 213	8·7	2·6	..	..	11·0	2·3	12·9	1·1	9·1	2·7	11·1	2·4	12·6	2·0	12·2	2·2
Co 214	12·5	1·3	..	..	15·8	0·8	16·7	0·1	15·7	0·9	16·2	0·8	16·8	0·8	15·8	0·8
Co 216	11·1	1·9	..	..	12·2	1·9	14·3	1·0	11·4	2·1	13·1	1·7	13·4	2·0	..	..
S 48	12·4	1·2	10·4	2·3	13·7	1·5	15·9	0·7	12·8	1·7	14·7	1·1	16·9	0·7	16·3	0·7

The figures give parts of sucrose and glucose per 100 parts juice.

* These results were obtained in outturn tests.

TABLE III.

Outturn tests of Coimbatore seedlings selected for field trial.

	Yield of cane maunds per acre		Juice expressed per 100 canes		Purity coefficient of juice		Sucrose per 100 canes	
	1920-1921	1921-1922	1920-1921	1921-1922	1920-1921	1921-1922	1920-1921	1921-1922
Co 204 ..	834	1,080	61·1	59·9	75·8	68·3	8·9	7·4
Co 205 ..	820	974	60·9	59·8	71·7	75·2	9·4	8·5
A 42 ..	634	732	61·0	55·9	84·8	86·0	12·4	12·4
Co 210 ..	1,052	1,002	63·8	64·4	77·7	79·8	9·3	9·7
Co 212 ..	1,002	965	68·2	66·8	86·2	82·0	11·3	10·6
Co 213 ..	1,176	1,198	67·9	65·9	80·8	78·7	10·4	10·0
Co 214 ..	925	1,008	64·3	62·2	85·0	86·3	13·3	12·4
Co 216 ..	719	..	66·3	..	79·3	..	11·1	..
S 48 ..	955	1,043	65·4	63·8	88·9	89·5	13·4	12·9

The comparison of the *rab* (*massecuite* as manufactured by the country process) is given in Table IV. The *rab* was made in a five pan Rohilkhand *bel* over an open fire, and the samples were taken from quantities of 7–12 maunds. *Rab* was made instead of *gur* because it is the usual product in Rohilkhand, and commands a ready market.

TABLE IV.

Composition of rab *of Coimbatore seedlings selected for field trial.*

	Per cent. sucrose		Per cent. glucose		Per cent. ash		Brix		Purity	
	1920-21	1921 22	1920-21	1921-22	1920-21	1921-22	1920-21	1921-22	1920-21	1921-22
Co 204	61·4	60·7	18·0	19·4	2·06	2·93	86·2	88·0	71·2	68·9
Co 205	62·3	66·5	17·7	14·2	2·85	2·94	87·0	88·8	71·6	74·9
A 42	72·9	71·3	8·5	9·4	2·37	2·75	87·8	88·0	83·0	81·0
Co 210	63·6	70·6	18·0	10·9	2·98	2·69	86·4	88·9	73·6	79·4
Co 212	68·6	70·7	10·9	12·4	2·36	1·78	84 6	88·2	80·9	80·2
Co 213	67·6	66·5	17·0	15·4	2·34	2·16	88·2	84·3	76·6	78·8
Co 214	69·1	72·5	8·9	7·8	2·65	2·30	85·4	88·6	82·0	81·8
Co 216	65·3	..	17·2	..	2·44	..	85·6	..	76·3	..
S 48	73·9	75·5	8·4	6·2	1·09	1·55	86·4	85·7	85·6	88·1

(*b*) *Series Co* 218–*Co* 223.

The results obtained with the second series of seedlings received in 1919 are given in Tables V, VI and VII. These seedlings have been under observation for three seasons, and four of them have been on a field scale for one season. The tests are therefore not completed, and a final opinion cannot be expressed regarding them. It may be stated, however, that the agricultural characters of this series are (with the exception of Co 220) better suited to the conditions of the United Provinces than those of many of the first series. The second series consists of medium canes suitable for improved cultivation.

TABLE V.

Ripeness tests of Coimbatore seedlings received in 1919.

	1919–1920		1920–1921						1921–1922			
	23rd Jan., 1920		18th Nov., 1920		18th Dec., 1920		6th Jan., 1921		18th Nov., 1921		24th Dec., 1921	
	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
Co 218 ..	17·2	0·1	14·5	0·9	15·1	0·9	16·1	0·5	14·4	1·6	14·6	1·5
Co 219 ..	12·0	1·6	8·9	2·4	10·0	2·5	12·1	1·7	10·7	2·5	11·2	2·4
Co 220 ..	14·3	0·9	..	..	..	..	..	..	..	..	..	..
Co 221 ..	15·1	1·0	13·8	1·7	14·2	1·6	15·9	0·6	14·0	2·3	14·9	1·7
Co 223 ..	13·5	0·6	10·3	2·0	10·5	2·1	12·7	1·3	11·0	2·4	11·9	1·8

The figures give parts of sucrose and glucose per 100 parts cane.

TABLE VI.

Outturn tests of Coimbatore seedlings received in 1919.

	1921–1922			
	Yield of cane maunds per acre	Juice expressed per 100 canes	Purity coefficient of juice	Sucrose per 100 canes
Co 218 ..	872	65·1	85·1	11·5
Co 219 ..	1,198	66·5	79·1	9·3
Co 221 ..	909	63·3	84·3	12·0
Co 223 ..	1,053	63·5	81·7	9·5

TABLE VII.

Composition of rab *of Coimbatore seedlings received in* 1919.

	Per cent. sucrose	Per cent. glucose	Per cent. ash	Brix	Purity
Co 218 ..	72·1	11·0	2·35	89·0	81·0
Co 219 ..	67·5	15·9	1·87	87 5	77·1
Co 221 ..	70·9	14·5	1·44	88·8	79·9
Co 223 ..	67·9	16·0	1·52	87·8	77·3

III. DISCUSSION OF RESULTS.

It has been stated above that the agricultural characters of the seedlings selected for field trial did not differ widely. The ripeness tests, the outturn and milling tests, and the examination of *rab* enable a definite opinion to be formed regarding their value as sugar producers.

An elaborate discussion of the results tabulated in the attached tables is not necessary. To any one interested in sugarcane cultivation and sugar production the tables themselves give the necessary information. It will be sufficient if attention is drawn to one or two points of special interest.

The shortness of the crushing season handicaps the extension of sugar production in Upper India. It affects both the manufacturer and the cultivator. In normal seasons the crop of mixed varieties of cane grown in the Rohilkhand and Meerut Divisions of the United

Provinces is not ready for crushing before the last week in December. In Gorakhpur and Bihar crushing begins somewhat later.

The operations must be finished before the harvesting of the winter (*rabi*) grain crop, which commences in the middle of March. The period during which cane harvesting operations are in full swing, is on the average about 85 days. It is therefore a matter of importance to select a cane which matures early in the season. The introduction of such a cane will enable the manufacturer to lengthen the working season, and will enable the cultivator to take advantage of the *gur* market when prices are at their highest point.

A reference to Table II will show that A 42, a cane isolated from the mixture of varieties grown in the Mahamdi Tehsil of the Kheri District, ripens remarkably early, and is ready for crushing in the first week in November. It is a thin cane of good quality in all respects. The yield is limited, under the most favourable conditions as regards cultivation, to about 700 maunds per acre. It cannot be more intensively cultivated without deteriorating in quality. It is, however, a great improvement on the majority of indigenous canes, and is a good example of the benefit that can be obtained by the simple selection of the best existing types.

One of the seedling canes Co 214 matures early as will be seen from the ripeness tests in Table II. It is a medium cane and responds to improved cultivation. Yields of 1,000 maunds of cane per acre have been obtained during the two years it has been on a field scale. Co 214 stands out prominently as the best sugar producer of the series Co 201–Co 216. The results obtained during the four years it has been under observation have been consistently satisfactory. It has good agricultural characters, and is easy to grow either on the flat or in trenches. It arrows profusely at harvest time.

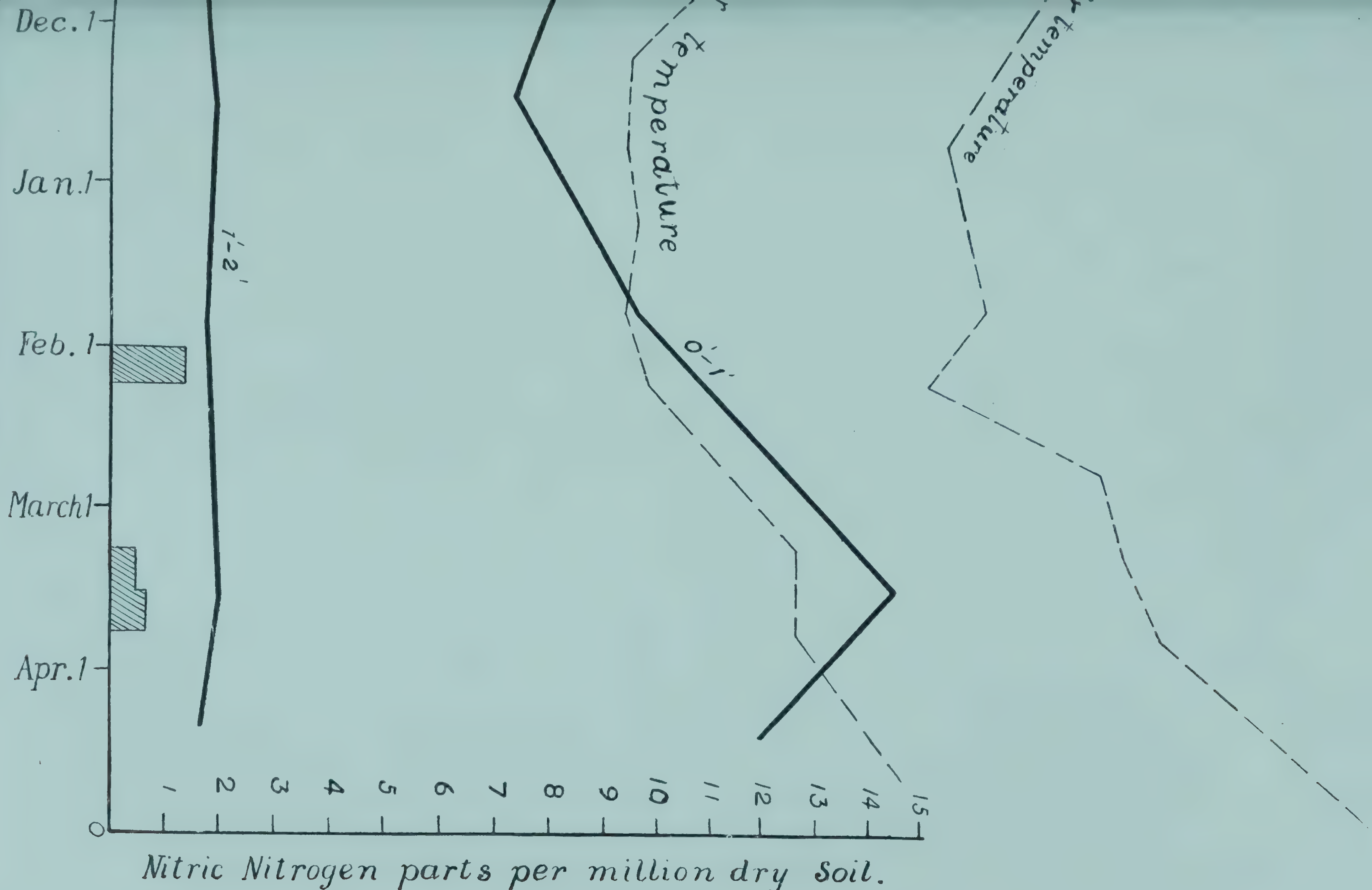
It was noticed in two consecutive years, when large quantities of juice were handled, that the latter darkened quickly on standing in the storage tanks, probably due to the action of an oxidase. This is a defect in an otherwise excellent cane. The juice is not difficult to clarify, but when it is clarified it is slightly dark in colour. This affects the colour of the *rab* but not (as will be seen from the analysis in Table IV) the composition of the latter which, as regards sucrose,

purity and crystals, is of good quality. This defect will probably not be serious in factories employing modern methods, and will be more than compensated for by the other desirable qualities possessed by this seedling. If Co 214 is selected for trial on a factory scale in Bihar, it is recommended that its keeping qualities should be tested.

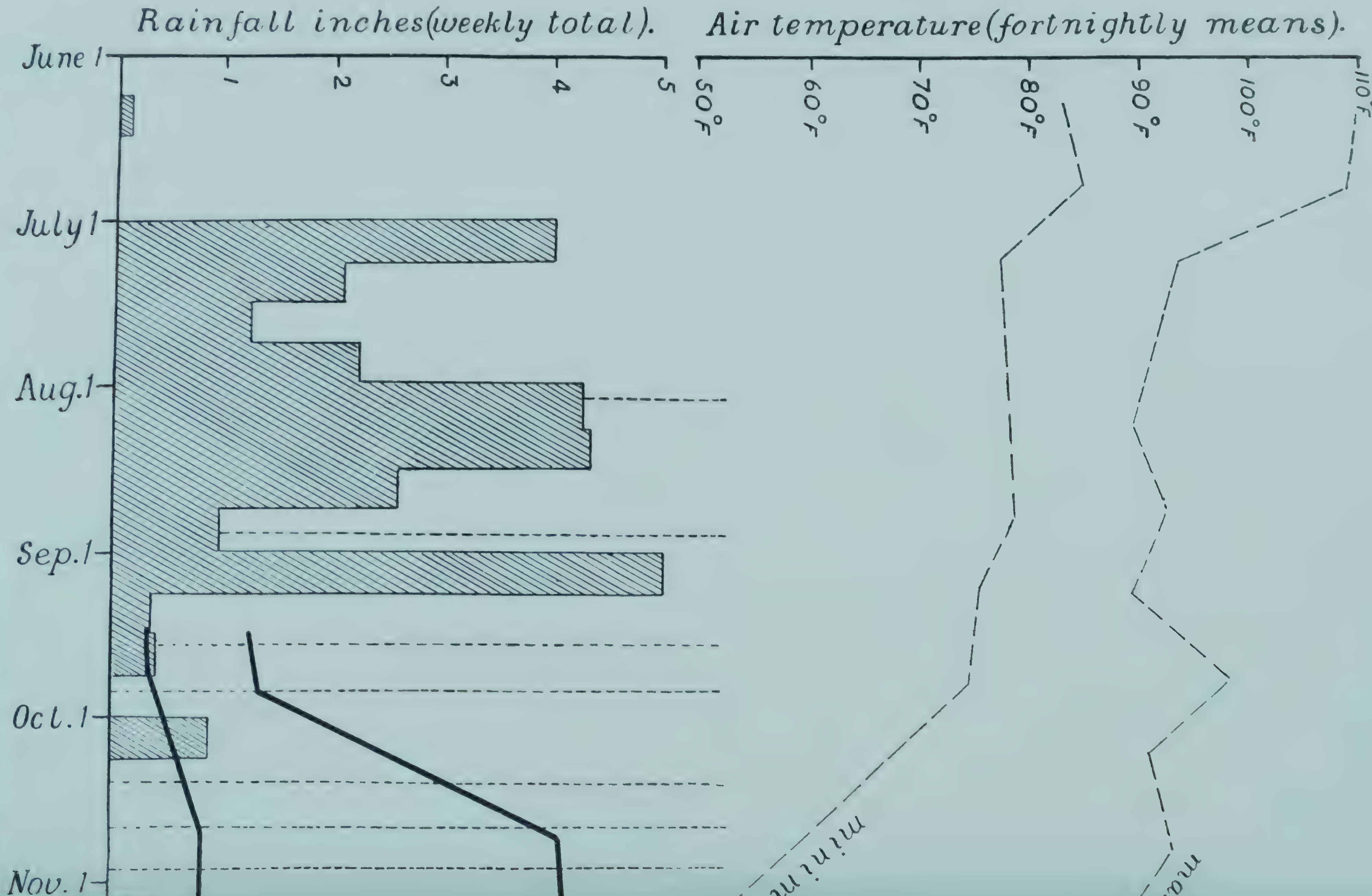
Co 214 *is the selection definitely made at Shahjahanpur from the series Co* 201–*Co* 216 *for extended trial in the United Provinces.*

The general character of the remaining seedlings of this series is a heavy yield of poor quality cane. None of them ripen by the time crushing operations are in full swing in the United Provinces, and none of them possess sufficient capacity as sugar producers to justify their introduction. The cost of handling canes of this quality would prohibit their general cultivation, whether they were crushed by the cultivator, or transported to a central factory. Additional fuel was required to boil down the juice of all Coimbatore seedlings with the exception of Co 214 although they had a fibre content of the same order as other canes grown at Shahjahanpur. Several of them were attacked by smut (*Ustilago sacchari*), a pest which may cause considerable damage. Co 203, Co 207 and Co 209 were almost completely destroyed by it, and Co 212 and Co 213 were attacked in the first season.

The composition of the *rab* gives a measure of the quality of *massecuite* that would be produced in the factory, and of *gur* if the latter is made. It is true that there would be a difference between the *rab* and *massecuite* due to evaporation in vacuum pans and the concentration to a higher "*Brix*" than is possible in open pans. The relative composition would, however, be the same. Factory managers will probably find the analysis of the *rab* the best means of forming an opinion of the relative value of the seedlings from the manufacturing point of view. The composition of the *rab* is closely related to that of the juice from which it is made. There is one factor affecting the value of *gur* and *rab*, and in a less degree *massecuite*, which cannot be determined by analysis, *viz.*, colour. This does not depend entirely on the analysis of the juice, and the amount of glucose or salts, which the latter contains. The *rab*



ORE, SEPTEMBER 1919—APRIL 1920.
l was cultivated as explained in the article.



NITRATE ACCUMULATION,
The vertical broken lines indicate

made from the Coimbatore seedlings and the two Shahjahanpur varieties S 48 and A 42 was graded as regards colour into three qualities:—

Grade I.	*Grade* II.	*Grade* III.
Co 212	Co 210	Co 204
Co 213	Co 214	Co 205
S 48	Co 216	
A 42		

Grade I is average, Grade II is slightly below average, and Grade III very much below average quality of local *rab* as regards colour.

The juice of Co 212 and Co 213 contained more glucose than that of Co 214, but Co 212 and Co 213 gave Grade I *rab* and Co 214 Grade II *rab* on a colour basis. The reason for this, as explained in a preceding paragraph, is the rapid darkening of the juice in the storage tanks.

IV. Summary.

The results of the systematic examination of the first series of Coimbatore seedlings may be regarded as satisfactory. They were the first seedling canes produced and tried on a field scale in India, and experience of the behaviour of the various types had to be gained. The majority of the seedlings proved to be of poor quality, but one seedling (Co 214) of considerable merit has emerged from the rigorous tests applied, as a type of cane suited to the conditions of at least one important sugar tract in the United Provinces.

A high standard is undoubtedly set as regards sugar content and purity of the product by the best indigenous canes of the United Provinces, and it is in this respect that the Coimbatore series Co 201–Co 216 chiefly failed.

A wide range of canes is required to meet all the conditions of soil and cultivation in the United Provinces, and a larger proportion of successes would be probable if a wider range of crosses were made.

The expense involved in carrying out a series of tests, such as those described above, is considerable. At present the behaviour

of a seedling, selected at Coimbatore for distribution in the United Provinces, seems to be a matter of chance. It is desirable to carry out a more effective and rigorous preliminary selection, and to eliminate in the preliminary stages seedlings so obviously unsuitable as Co 203, Co 207, Co 209 and Co 211.

The authors desire to express their thanks to Mr. Howard, Imperial Economic Botanist, Pusa, for his valuable assistance and advice during the preparation of the paper.

NITRATE FLUCTUATION IN THE GANGETIC ALLUVIUM AND SOME ASPECTS OF THE NITROGEN PROBLEM IN INDIA.

BY

G. CLARKE, F.I.C.,

S. C. BANERJEE, F.C.S.,

Khan Sahib MOHD. NAIB HUSAIN,

AND

Khan Sahib ABDUL QAYUM,

Agricultural Department, United Provinces.

Climatic conditions—temperature and rainfall—determine the agricultural calendar as well as the character of the growth season and the nature of the crop. These factors are beyond control. When they are favourable, the art of cultivation consists in managing the soil so that its condition as regards aeration, texture, moisture, and content of organic matter is such that the changes produced by soil organisms proceed in the required direction at the right rate and the root system of the crop develops early and to its maximum extent.

A remarkable feature of the agricultural year in Upper India is the rapidity with which the seasons change, and the wide variation in their character. This is prominent in the north-west of the United Provinces where the authors have worked for many years.

The change from the arid conditions and high temperatures prevailing in April, May and early June, before the break of the

south-west monsoon, to the tropical conditions which exist when the summer (*kharif*) crop is sown at the end of June and the beginning of July; and the change from high humidity, high temperature and saturated condition of the soil at the end of the monsoon rains in September, to the temperate conditions occurring when the autumn (*rabi*) wheat sowings take place, stand out in striking contrast to the gradual transition from winter to spring and summer in Europe.

This rapid change of season gives rise to two conditions which profoundly affect agricultural practice in the United Provinces and the methods that can be followed to influence its improvement and intensification. In the first place, a very short time is available for the preparation of the land; secondly, the period of active growth of the crop is limited. The former influences the methods of cultivation, the latter the selection of varieties.

An example of the wide variation in the character of the two agricultural seasons in the United Provinces is afforded by the fact that wheat and sugarcane are grown on adjacent fields.

The principal soil factors determining crop yield, with the exception of soil moisture, are most easily controlled during the preparation of the land. It is then that the food supply derived from the soil, notably the nitrate, is made available. When the crop has been sown, control is limited to maintaining soil moisture, and in a less degree air supply, by inter-cultivation until the growth of the crop puts an end to further operations, and to supplementing the deficiency in soil moisture by irrigation.

The biological processes of the soil of a tract, such as the United Provinces, will differ from those of a temperate climate, both in intensity and time of occurrence, as a result of the wide seasonal variations referred to above. It is probable that they will be more rapidly affected by conditions produced by cultivation, such as regulation of air supply and soil moisture.

The production of nitrates is one of the most obvious and characteristic changes produced by living organisms in the soil. It is also the end point of a series of changes which are a fairly reliable index of biological activity.

As pointed out by E. J. Russell,[1] "The nitrate supply in the soil is very commonly in Great Britain a limiting factor in crop production, and any process which increases nitrate supply tends to increase productiveness and *vice versa*............No soil constituent, not even soil moisture, shows such great fluctuations as nitrates, and none is so susceptible to external influences."

In Upper India, moisture is very commonly the limiting factor in crop production. The efforts of the agriculturist are concentrated on conserving this and on supplementing the natural supply by irrigation. When, however, sufficient moisture is available, the amount of nitrate will become a limiting factor. The storing up of soil moisture alone, and the addition of water, are not sufficient for the purpose of obtaining maximum crop yields. If the maximum benefit is to be derived from irrigation schemes, attention must be paid to other factors, including those governing the supply of nitrates, particularly during the early stages of growth.

The fluctuations observed in nitrate content of uncropped cultivated soil of the Gangetic plain during the cold weather (*rabi*) season, are recorded in this paper.

The observations were made at Cawnpore in 1919-20, commencing on September 14th, 1919, at the close of the monsoon rains, just before cultivation operations for sowing the cold weather cereal crops became general. They were continued until April 12th, 1920, when these crops were harvested.

The original intention was to continue the observations throughout the year, and to obtain a complete record of the annual fluctuations in nitrate content of uncropped cultivated soil. This, however, had to be postponed owing to the appointment of one of the authors to the Indian Sugar Committee and later to other duties.

The land available for the experiment was Gangetic alluvium, situated on the farm of the Agricultural College, Cawnpore, three miles from the river Ganges. The soil is a very heavy and stiff loam, such as is commonly found in this tract near the banks of

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[1] *Jour. Agri. Sci.*, vol. VI, 1914, p. 18.

the river. This soil has been subject to erosion in former times, and much of the lighter material has been washed away. It is now protected from further injury by small embankments. The first ten feet or so from the surface may be interspersed at irregular intervals (1) with shallow layers of very fine soil material which possesses distinctly colloidal properties, and through which water percolates with difficulty, and (2) with layers of nodular calcium carbonate (*kankar*). At greater depths, hard layers of clay, several feet thick, and deposits of water bearing sand are found. The water level is approximately thirty feet from the surface. A description of this soil is given in *Records of Drainage in India* by J. W. Leather. [1]

The field in which our observations were made is situated about a quarter of a mile from the drain-gauges referred to by Leather. The field had been continuously under crop for many years, and as far as could be ascertained had never been manured. It had yielded over a long series of years a crop of wheat (980 lb. per acre). The cultivation had been identical with that of the neighbouring cultivators' fields with the exception that deeper ploughing—4″ instead of $2\frac{1}{2}$″ to 3″—had been customary during the preparation of the land for sowing.

The nitrogen content of the soil is given below :—

0 – 1 foot	0·0378 per cent.
1 – 2 feet	0·0336 per cent.

Method of obtaining samples and estimating nitric nitrogen.

A position was selected in the field where the crop in the previous year had been uniform. A 2″ diameter boring was taken to a depth of two feet. Each foot was collected separately for the estimation of nitric nitrogen. Successive borings were taken at distances of not less than two feet and not more than three feet from the first boring.

Leather[2] had pointed out in the paper already referred to that conclusions are based on small soil columns by this method

[1] *Mem. Dept. Agri. India, Chem. Ser.*, vol. II, 1911, p. 67.
[2] Loc. cit.

of obtaining samples. Such samples are admittedly not suitable for the rigid comparisons required to construct a nitrogen balance sheet. They give, however, the information we required, *viz.*, an indication of the time of occurrence and the intensity of nitrification in soil *in situ* during the cold weather season.

This method was used by Leather in a series of observations on the nitrate content of Pusa soils which are discussed below, and by J. N. Sen[1] in examining the soil of lysimeters at Pusa. It may be mentioned that a fair amount of uniformity is known to exist in the nitrate content of a plot that has been uniformly treated, except in the case of heavily dunged plots where, owing to the difficulty of getting regular distribution, the variation is greater.[2]

The samples were spread out on paper in the field for a few minutes until sufficiently dry to be gently powdered. Less than an hour elapsed from taking the sample to the sterilization of the extract containing the nitrates in the laboratory. All samples were treated in exactly the same manner. 600 grm. of soil was used for the determination of nitric nitrogen and 100 grm. for the estimation of moisture—1 c.c. of nitric oxide gas corresponding roughly to 1 part of nitric nitrogen per million of soil.

Nitric nitrogen was estimated by Schloesing's method as described by Warrington.[3] This method has fallen into disuse of late years being considered troublesome to carry out. Modern refinements in apparatus for manipulating small quantities of gas now enable the operations involved to be performed very expeditiously. The resulting nitric oxide can moreover be analysed in a few moments by mixing with pure oxygen, thus giving a decisiveness not possessed by colorimetric methods. Fourteen determinations of known quantities of nitric nitrogen varying from 2 to 10 milligrams gave a mean recovery of 99·57 per cent. of the nitrogen taken.

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[1] *Jour. Agri. Sci.*, vol. IX, 1918, p. 32.

[2] *Jour. Agri. Sci.*, vol. IV, 1914, p. 55.

[3] *Jour. Chem. Soc.*, vol. XLI, 1882, p. 345

Estimations of nitric nitrogen in samples of soil gave the following results :—

	Parts nitric nitrogen per million soil
Soil No. 1	28·45
	27·98
	28·00
Soil No. 2	37·47
	37·26
Soil No. 3	6·60
	6·67

RESULTS OF COLD WEATHER OBSERVATIONS.

The results obtained from September 1919 to April 1920 are given in Table I.

TABLE I.

Date	Nitric nitrogen parts per million (dry soil)	
	0′ – 1′	1′ – 2′
September 14th, 1919 ..	2·4	0·6
September 26th, 1919 ..	2·6	0·6
October 22nd, 1919 ..	8·1	1·5
November 17th, 1919 ..	8·3	1·5
January 15th, 1920 ..	7·4	1·8
January 26th, 1920 ..	9·8	1·6
March 15th, 1920 ..	14·4	1·9
April 12th, 1920 ..	12·0	1·6

The cultivation operations after the wheat harvest of March 1919 were as follows :—

May 12th	Ploughed to a depth of 4 inches.
August 2nd	ditto.
August 28th	ditto.
September 17th	ditto.
September 25th	Ploughed to a depth of 3 inches, surface consolidated with wooden beam.
October 11th	ditto.
October 20th	ditto.
October 27th	ditto.
November 21st	ditto.

The results of our observations of nitric nitrogen fluctuation together with weekly totals of rainfall (inches) and fortnightly averages of maximum and minimum air temperature (0°F.) are shown graphically in Plate XXVII.[1]

The statement of agricultural operations will be self-explanatory to Indian readers, but for the benefit of those unfamiliar with Indian conditions a word of explanation is needed. The autumn sown crop of wheat was harvested in March 1919 ; cheap irrigation being available, the land was ploughed and left open during the hot, dry months of April, May and June. The maximum air temperature at this period may reach 118°F., and the soil is thus exposed to conditions unfavourable to active life during the summer fallow. During the rainy season (July, August, September), cultivation, which consisted of light ploughing and consolidation of the surface with a heavy wooden beam drawn by oxen, was carried out when weather conditions permitted.

As soon as the monsoon receded, and the land became sufficiently dry, systematic preparation for wheat sowing in October commenced. At this period of the year, the countryside becomes in a few days the scene of intense activity, not a moment being lost by the cultivators in taking measures to conserve the soil moisture and, as our observations prove, to prepare the supply of nitrate necessary for the forthcoming cereal crop.

Discussion of results.

The point of interest in our observations is the fluctuation in the amount of nitrate in the first foot of soil. After a slight increase in October during the cultivation operations, the amount in the second foot showed no variation. *The rapid accumulation of nitrate in the first foot in October during the preparation of the land for autumn (rabi) sowing is clearly brought out.* Nitrate had almost completely disappeared from the first foot at the end of the rains, and increased from 2·6 parts per million on September 26th to 8·1 parts per million on October 22nd.

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[1] Meteorological data are taken from records published in the *Report of Experimental Stations, Central Circle, United Provinces*, 1920.

Our observations are in agreement with those recorded by Pouget and Guiraud[1] at Maison Carée, Algiers, under somewhat similar conditions as regards rainfall.

The dry weather of 1919 set in by the middle of September at Cawnpore, the last heavy fall of rain, 1·78", occurring on September 8th. The land was dry enough for cultivation operations to be in full swing on September 17th. The most rapid accumulation of nitrate occurred between September 26th and October 22nd. Soil temperature was favourable for nitrification throughout September and October. Other controlling factors must, therefore, be looked for to account for the absence of any evidence of nitrate formation in September, and its rapid accumulation in October. Insufficient air supply and excess of soil moisture are indicated as the most probable. During the heavy downpours of the rainy season, the soil had become tightly packed. When dry weather set in, a hard crust (*papri*) formed on the surface, effectively cutting off the supply of air. The soil, moreover, if not actually saturated with water had, through the rains, contained considerably above the optimum for the active growth of the series of organisms concerned in nitrate production. The cultivation operations in October immediately changed these conditions. Soil moisture was reduced by evaporation and the soil was thoroughly aerated.

In an interesting series of experiments carried out in lysimeters at Pusa, J. N. Sen[2] has shown that rapid nitrate accumulation occurred in October and November, a period when the climatic conditions at Pusa correspond to those of September and October at Cawnpore. He drew attention to the fact that the period of rapid nitrate accumulation coincided with one of the periods of active growth in Bihar. Sen's experiments were carried out for a special purpose, under admittedly artificial conditions, but they add considerable support to our own observations made in the field, that the period immediately preceding the autumn sowing time is one of rapid nitrate accumulation in cultivated land.

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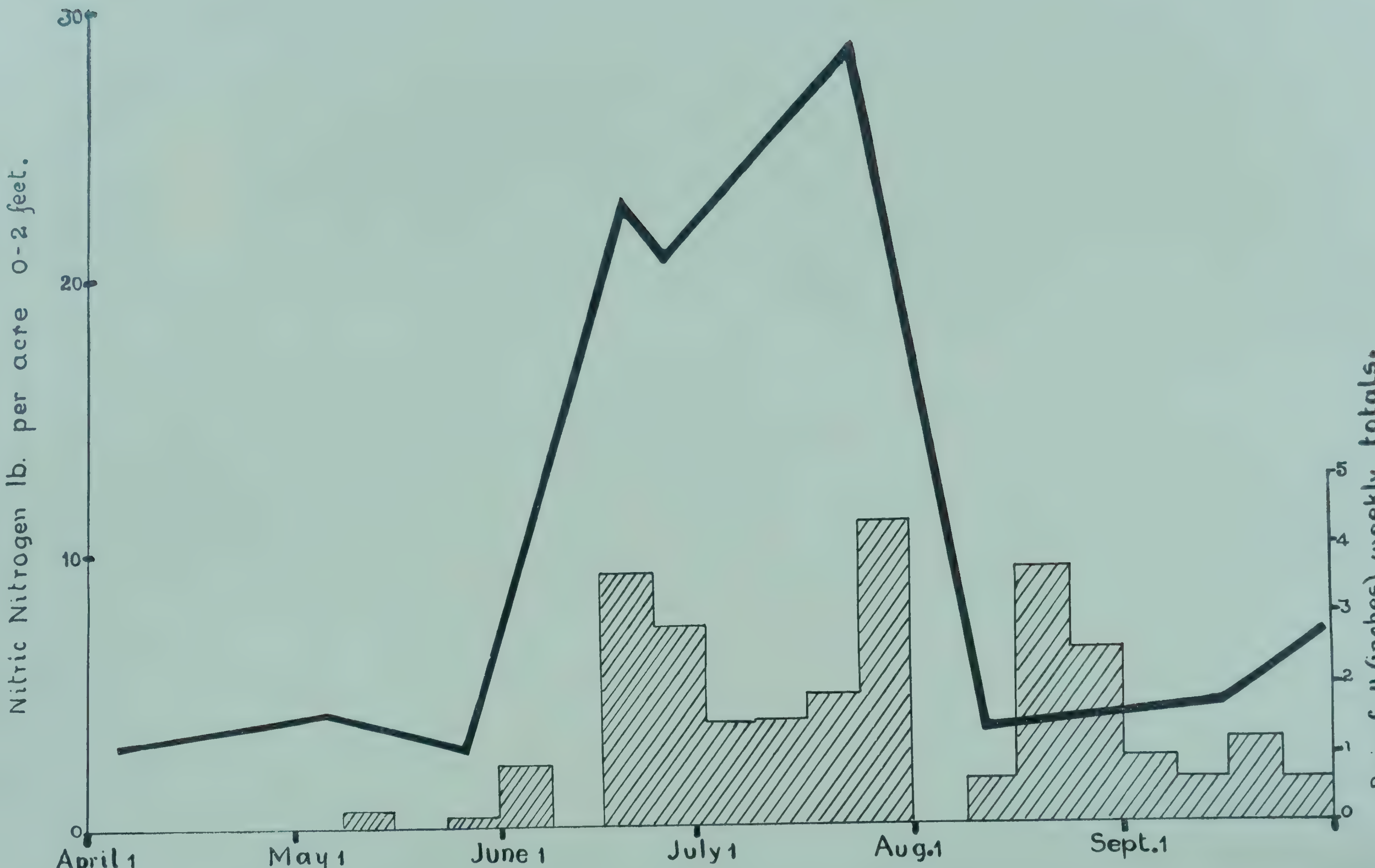
[1] *Comptes Rendus*, vol. CXLVIII, 1909, p. 725.

[2] *Jour. Agri. Sci.*, vol. IX, 1918, p. 41.

PLATE XXVIII.



NITRATE ACCUMULATION, PUSA, APRIL—SEPTEMBER 1910.

Systematic estimations of nitrate to a depth of 9 feet were made by Leather[1] at Pusa from April 4th, 1910, to October 25th, 1910. He unfortunately gives no details of the treatment of the fallow plot from which his samples were taken, beyond stating that it was kept free from weeds and lightly cultivated.

Very rapid nitrate accumulation was observed after the first fall of rain in June, and no further marked increase was noticed throughout the rainy season which extends at Pusa to the middle of October. The results obtained in the upper two feet of soil are shown graphically in Plate XXVIII. These are of great interest, as they bring out the point that a period of rapid nitrate accumulation occurred at Pusa at the commencement of the monsoon rains, and immediately preceding the sowing of the summer (*kharif*) crop.

The view expressed by Leather that nitrification only occurs at the commencement of the monsoon, and then only for a short time, cannot, however, be accepted, and indeed is hardly justified by the observations recorded, which were not continued on cultivated land during the period of preparation for the *rabi* crop. If nitrification in cultivated land were active only during the wet weather, and then only for a short time, it is obvious that winter crop production at Pusa would be reduced to a very low figure.

From the evidence available the conclusion is arrived at that, under the ordinary system of cultivation in Upper India, conditions are favourable for rapid nitrate accumulation at two seasons: (1) immediately after the first rains of the south-west monsoon in June or July, and (2) at the beginning of the cold weather season in October. These months coincide with the beginning of the two agricultural seasons, and occur just before the sowing of the summer (*kharif*) crop and the cold weather (*rabi*) crop.

Both the summer and autumn periods of nitrate accumulation are preceded by conditions unfavourable to active life in the soil.

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[1] *Mem. Dept. Agri. India, Chem. Ser.*, vol. II, 1911, p. 101.

The summer period is preceded by the intensely hot and dry months, April, May and early June, when a maximum air temperature of 118°F. is not uncommon. During these months, the upper surface of soil, unless irrigated, is deprived of soil moisture. Where hot weather cultivation is practised, and the soil is left in a thoroughly aerated condition, during April and May, the conditions will be particularly favourable to very rapid nitrification, during the summer period of nitrate accumulation, and therefore to a high yield of the succeeding (*kharif*) crop. The autumn period of nitrate accumulation is preceded by three months of excessive rainfall, during which the soil is frequently saturated with moisture. The conditions are such as to interfere with proper aeration, and distinctly unfavourable to aerobic organisms.

A typical curve for nitrate accumulation was obtained at Cawnpore during the period September to April (Plate XXVII). When the conditions unfavourable to nitrification ceased, and favourable conditions set in, rapid nitrate accumulation took place, followed by a period of sluggishness, and then by one of renewed activity. The curve (Plate XXVIII) obtained from Leather's results at Pusa, for the period April to September, shows the same characteristic but in a less marked manner.

The principles which control nitrate accumulation are of general application, but the manner in which they operate depends on conditions determined largely by geographical position. For example, the processes concerned may be retarded by the cold and wet of the European winter, the intense heat and dryness of the Indian hot weather, or excessive rainfall such as occurs for definite periods in countries affected by the monsoon. They are accelerated in India by the conditions mentioned in the preceding paragraphs.

The amount of nitrate present during the growth of the crop has a direct bearing on the yield. Nitrate formation in the soil is an essential phase of the nitrogen cycle as far as the majority of food crops are concerned. The factors which influence nitrification in different parts of the world, are, therefore, of economic importance and closely related to food supply. Data relating to

nitrification in tropical and sub-tropical countries would add an interesting chapter to Agricultural Science. Records regarding the intensely cultivated sugarcane fields of Java would be of special interest. The latter crop follows rice and yields forty tons of sugarcane per acre.

The Indian cultivator turns parts per million of nitric nitrogen in the soil into maunds of grain per acre. In the United Provinces, for the cold weather crop at any rate, he has probably adapted his methods to accumulate not more than sufficient nitrate for a crop, to which a limit is normally set by soil moisture.

The system of agriculture at present practised in Upper India has established a position of equilibrium in which the nitrogen removed by the small crops produced, and the inevitable losses of nitrate by leaching and imperfect surface drainage during the rains, are balanced by the recuperative agencies which add nitrogen to the soil. There is no evidence that cultivated land is either losing or gaining in fertility. Much of it seems to have reached a position comparable to the permanently unmanured wheat plot at Rothamsted, which for the fifty years preceding 1911 gave an average yield of 12·5 bushels (equal to 9·45 maunds) per acre.

The existing system of agriculture has been aided of late years in many ways by the Agricultural Department, by the introduction of better varieties of crops, by extensive seed distribution, and by increased facilities for irrigation ; but no general change in agricultural practice has been made resulting in an increase in fertility. The next step forward is the establishment of a permanent system of agriculture at a higher level of production than the existing one. When this is started, and only then, shall we begin to get the full benefit of improved varieties of crops and the organization for seed supply which has been established by Government.

The results obtained at the Sugarcane Experiment Station, Shahjahanpur, remove any doubts which might exist regarding the possibility of profitably intensifying agriculture in the United

Provinces. The average yields of the three crops grown in rotation for the seven-year period, 1915–1922, are given below :—

Sugarcane	..	..	841 [1]maunds per acre.
Wheat	..	..	30·3 " "
Gram	..	..	24·1 " "

The standard outturn that may be expected on irrigated land in the United Provinces in a year of average character is as follows :—

Sugarcane	..	..	345·4 maunds per acre.
Wheat	..	..	15·2 " "
Gram	..	..	11·6 " "

This does not, however, provide a complete solution because extraneous nitrogen (approximately 100 lb. per acre) has been introduced once during the four-year rotation. The use of nitrogenous manures, in the form of oilcake meal for example, is increasing and will increase, but the time is remote when the supply, however carefully controlled, will be sufficient to fertilize all the cultivated land. Except where capital is forthcoming for the production of high priced crops, such as sugarcane, we must aim, in the first instance, at a lower general standard of production than the results just quoted indicate, but at the same time one which will be a great advance on the existing standard.

The authors believe this to be attainable if the problem is seriously attacked. The possibility of speeding up, by suitable systems of cropping and cultivation, every recuperative process, which adds nitrogen to the soil, must be fully explored. There is every reason to believe from the study of drain-gauge records, and other investigations, that these are considerable in India, if the soil is maintained in a suitable condition. That they operate is obvious, otherwise a soil containing approximately 1,500 lb. of nitrogen per acre foot, which has been cultivated for centuries without any addition of extraneous nitrogen, would have become unproductive years ago.

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[1] 1 maund = 82·3 lb.
27·2 maunds = 1 ton (2,240 lb.)

A great opportunity exists in the United Provinces for the study of the problem in those tracts where effective steps are now being taken to overcome the scarcity of water, for example, in the magnificent stretch of country, 6,400,000 acres[1] in extent, commanded by the Sarda Canal project, and also in areas where tube well installations are concentrated.

The problem is undoubtedly complex, and it is unnecessary to dwell on the need for scientific investigation in connection with it. Special care must be taken to guard against the introduction of methods of cultivation unsuited to Indian conditions, which lead to waste by producing nitrates far in excess of the requirements of the crop, and which by disturbing the levels lead to loss by denitrification during the rains. The risk of considerable loss from the former cause is by no means to be ignored in Upper India with its two agricultural seasons and two periods of active nitrification annually. It has recently been shown that accumulation of nitrate far in excess of the crop requirements does actually occur in Egyptian cotton fields.[2]

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[1] It is estimated that 21 per cent. (or about 1,350,000 acres) will be irrigated annually (*Rept. of the Indian Sugar Committee*, 1921, p. 33).

[2] *Jour. Agri. Sci.*, vol. IX, 1919, pp. 226–227.

A NEW SOURCE OF MANURE.

BY

K. ADINARAYAN RAO, L. Ag.,

Assistant to the Government Agricultural Bacteriologist, Madras.

Agriculture is the mainstay of more than 80 per cent. of the population of India. Its success mainly depends upon increasing or at least keeping up the fertility of the soil which is a necessary condition in crop production. In fact, increased crop production is the aim of all engaged in the pursuit of agriculture, and it is the resultant of many forces, chiefly biological, operating in the soil, often opposed to one another. Anything that interferes with the right working of these forces spells disaster to the ryot, for it means diminished or no crop at all. It is therefore of the utmost importance to know what these forces are and how they can be controlled to get the best results in the production of food.

It is a well-known fact that there are many essential elements necessary for the normal healthy development of a plant. Of these, nitrogen needs our anxious attention as it is very largely removed from the soil by each crop. Furthermore, our soils—especially the South Indian soils—are generally found to be deficient in this most necessary and important element of plant food.

As early as 1897 Sir William Crookes sounded a note of warning when he drew the attention of the scientific world to the possible depletion of the sources of nitrogen supply and the consequent danger to humanity at large in the near future, were not prompt measures taken to find ways and means to utilize the unlimited supply of air nitrogen for the production of suitable nitrogenous compounds to be made use of as fertilizers in agriculture.

This led to investigations by other scientists, and three industrial processes, namely, the arc process, the cyanamide process and the Haber process, have become prominent now-a-days. They are defective, however, in that farmers with small means cannot be profited by them.

The ryots at any rate in this country have understood the uses of bulky organic matter for replenishing their soils and have made use of certain green leaves, green crops, leafmould, etc., as manures. This is a useful practice no doubt but it is not always applicable as, for instance, to conditions arising from defective rainfall or other climatic factors over which the ryot can possibly have no control. Therefore, there arises a necessity for attempts at manufacturing new fertilizers under controlled conditions.

The scientific studies with the utilization of organic wastes as manures by bacterization are of great interest and open up many attractive and useful lines of investigation.

The point of practical importance here is, that the character of the organic matter and the bacteria present in a manure are of the greatest importance to agriculture. It is thus evident that organic manures become all the more indispensable. Efforts have been, therefore, made to utilize the available organic wastes as manures after being subjected to bacterial action. Up to the present no work of the kind has been done in India, and this preliminary note is simply a statement of what has been attempted with sugarcane waste by the author while working as a research scholar under Mr. Hutchinson, the Imperial Agricultural Bacteriologist at Pusa, and of what is to be done in the future with this and similar vegetable wastes.

It might be mentioned in this connection that transporting becomes the limiting factor in dealing with bulky manures. If such manures could be reduced in weight at the expense of their non-nitrogenous materials like the carbohydrates they may successfully compete with less bulky manures like fish manure or oil-cakes. Further, the cellulose-decomposition products and the sugars become possible sources of energy for nitrogen fixation. In other

words, the bulky organic wastes could act as culture media for the nitrogen fixers.

With a view to test the possibility of these, cane-waste known as megasse was used for the purpose of the experiments to be described hereafter and the work done so far in that connection forms the subject matter of this paper.

Megasse is the waste material after the extraction of juice from sugarcane. It is at present being burnt by the cultivator for making *jaggery* but may be available for manurial purposes after bacterization.

Composition of megasse :—

	Per cent.	
Water	40—50	With 75 per cent. extraction.
Sugar	10	
Fibre	40—50	

The composition varies with the efficiency of the mill used in extracting the juice, the kind of cane (hard or soft) and the power used in extraction (animal or steam).

It is not economically possible to extract the sugar left in the megasse and hence it was proposed to use it as a possible medium for nitrogen fixation with a view to introduce it as a cheap manure in agriculture after proper treatment.

The treatment may be in three ways :—

(1) To introduce nitrogen-fixing organisms only.

(2) To treat the megasse with cellulose-decomposing organisms for a certain period and then sterilize to get rid of all the organisms and inoculate with only the nitrogen-fixers. The object is to get the nitrogen-fixing organisms to do their work by utilizing the cellulose-decomposition products as well as the original sugar (10 per cent.) contained in the megasse.

(3) To introduce both the cellulose-decomposers and the nitrogen-fixers at one and the same time and allow the organisms to act on the megasse conjointly.

Large quantities of megasse, 20–25 millions of tons, are available in India, and as laboratory experiments have given encouraging results, it should be possible to produce a useful

manure out of a substance which is at present a waste-product meant for purposes of burning only.

There is another phase of the problem to be considered; before utilizing the megasse for the production of a manure it is necessary to show other sources of fuel to replace it as it is at present used on the spot as fuel for *jaggery*-making.

Assuming that it will be available for manurial purposes when it is proved that it is worth more as a manure than as a fuel, the following experiments were started. Before describing these experiments it may be mentioned that there is another distinct advantage in using megasse as a manure, which is that all the ingredients taken by the crop are returned to the soil. Only the juice is expressed and the cane juice does not contain the products of the soil and the soil will not lose anything thereby. This point I wish to particularly emphasize taking into consideration the notoriously exhausting nature of the sugarcane crop and the crying need for manures by the cane-grower.

The following table shows the analyses of a few megasse samples :—

Sample No.	N Per cent.	CaO Per cent.	K_2O Per cent.	P_2O_5 Per cent.
1	0·24	0·101	0·31	0·166
2	0·34	0·103	0·30	0·160
3	0·23	0·100	0·19	0·130
4	0·16	0·085	0·185	0·12
5	0·24	0·140	0·23	0·13
6	0·23	0·120	0·28	0·145
AVERAGE ..	0·24	0·108	0·25	0·142

It might also be pointed out that megasse has another advantage over other wastes in that it contains 10 per cent. sugar which alone, when utilized fully by the nitrogen-fixing organisms, should be responsible for a fixation of 100 milligrams of nitrogen per 100 grammes megasse or even more when the most efficient strains and the best combinations of the well-known nitrogen-fixing organisms are ascertained.

EXPERIMENTAL.

For this purpose 20 lb. of megasse of a soft local cane (Rastali) were taken. About 4 lb. were thoroughly dried in the sun, sampled

and stored in jars. Saturation capacity, which works out to 500 per cent., was determined and half saturation (250 per cent.) was used for the experiments.

Getting pure cultures of nitrogen-fixers.

Pure cultures of *B. Radicicola* were obtained from sann-hemp nodules by plating after sterilization of the nodules in the following manner :—

The nodules were carefully washed in distilled water and dropped into a sterilized test tube, containing a few c.c. of warm mercuric chloride (temperature 40°C.). The test tube was then replugged with cotton wool and placed in a filtering flask fitted with a rubber cork. The flask was afterwards connected to the filter pump and the air exhausted till the solution began to boil. In this way all air bubbles present on the surface of the nodule were withdrawn, and on admission of air by disconnecting the pump the nodules were made to sink to the bottom of the test tube and the disinfectant solution was able to act on all portions of the nodule.[1]

The organism isolated under the anaerobic nitrogen-fixation experiments (which subject itself has been dealt with in another paper by the author) supplied the need for an anaerobic nitrogen-fixer.

Impure cultures of Azotobacter were used as pure cultures could not be obtained in time.

The slants of soil extract mannite agar, potato and mannite agar were used for cultivating the three nitrogen-fixers as they are the best media known at present for organisms (*i*), (*ii*) and (*iii*), respectively. Liquid cultures from these slants were made by means of sterile water and used as inocula.

The first series is as follows :—

(1) 25 grammes megasse + 63 c.c. water (control).
(2) Control + Clostridium 3 c.c.
(3) Control + Clostridium $1\frac{1}{2}$ c.c. + Azotobacter $1\frac{1}{2}$ c.c.
(4) Control + Clostridium $1\frac{1}{2}$ c.c. + Radicicola $1\frac{1}{2}$ c.c.
(5) Control + Clostridium 1 c.c. + Azotobacter 1 c.c. + Radicicola 1 c.c.

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[1] *Mem. Dept. Agri. India, Bact. Ser.*, I, p. 250.

The bottles were incubated at 30°C.

Nitrogen determinations were made from each, once a month, by taking equal quantities of megasse after drying.

The results are given in the following table :—

No.	1st Determination 7–2–1920 Mg. N per 100 grm. megasse.	2nd Determination 7–3–1920 Mg. N per 100 grm. megasse.
1	376·25	498·00
2	326·66	1211·50
3	301·00	1390·70
4	322·00	1309·00
5	308·00	1260·00
6 Original megasse ..	270·00	270·00 original or unacted megasse.

The above results show that the megasse now contains 1·39 per cent. nitrogen. That is to say, twice as much nitrogen as is contained in farmyard manure after being acted upon for 2 months only by the nitrogen-fixing organisms and it may be possible that more nitrogen will be fixed. The cellulose-decomposition products as well as the sugar that is still to be found in the bottles supply energy for the organisms in an increasing degree as decomposition proceeds and it may be safely presumed that more nitrogen will be fixed. The methods used here may be extended to other wastes like (1) prickly pear, (2) dry leaves, (3) straw, (4) saw-dust, etc., etc.

The problem seems to be full of possibilities and is worth further elucidation. The manurial needs in India are increasing every day and efforts may with advantage be directed to meet the needs of the Indian cultivator.

Summary.

1. Of all the wastes such as (1) straw, (2) dry leaves, (3) saw-dust, (4) megasse, (5) *mahua* (*B. latifolia*) refuse from distilleries, (6) prickly pear, etc., megasse was selected first as it contains about 10 per cent. sugar.

2. The results obtained so far have been encouraging. Prior to bacterial treatment megasse contained only 0·27 per cent. nitrogen. But after bacterization for a period of two months

only, the nitrogen content increased to 1·39 per cent. The loss in bulk was not determined so that the absolute gain in nitrogen cannot at present be stated. The increased amount of nitrogen is twice as much as is contained in farmyard manure.

It is proposed to apply all the methods now ascertained in the utilization of megasse to other wastes which may also become equally useful.

Fig. 1. View of the Egg-laying Competition pens.

Fig. 2. "The Daily Mail" Black Leghorns.

REPORT ON THE SECOND ALL-INDIA EGG-LAYING COMPETITION.

CONDUCTED AT THE U. P. MODEL POULTRY FARM, LUCKNOW, BY THE U. P. POULTRY ASSOCIATION.

BY

MRS. A. K. FAWKES,

Secretary, U. P. Poultry Association, and Poultry Expert to Government, United Provinces.

THE first egg-laying competition held in 1920-21 met with such success that the United Provinces Poultry Association determined to make this competition an annual fixture. Accordingly it was decided to hold a second test in the Association's farm commencing on the 1st November, 1921, and to invite competitors from overseas as well as from all parts of India. Some 119 entries were received—18 of these from prominent breeders in England. On the opening day of the test no less than 80 birds were penned, each in a single enclosure (Plate XXIX, fig. 1), and every bird received equable treatment with regard to feeding, housing and attention.

It was astonishing to note how quickly the birds started to lay—the cold season in the U. P. is very conducive to winter laying. The comparatively long day compared to the short winter day of colder countries seems to prove the theory of light affecting the laying properties of hens. As artificial lighting of poultry houses has proved efficacious in improving the winter laying of birds, so the 12 hours' daylight of the United Provinces brings up the average winter production of birds tested to double the average laid during a similar period in the British Isles.

The extremes of temperature were very great, varying from 40 degrees at night to 84 degrees in the day, and as the birds were housed under practically open air conditions their health kept at a high average. No deaths except two accidental ones occurred and no cases of any more serious illness than slight colds were registered.

All the birds kept on weight and condition in spite of the intensive nature of their housing but ample scratching exercise was afforded by means of the simple expedient of burying their grain feed daily in the sand litter on the floor of each pen.

The quality of the birds competing was of decidedly higher type than the majority of the birds entered in 1920 and the contest was a keen one, the runners-up all scoring to within an egg or two of the highest record. The record for the three months of the test was a score of 69 eggs in 92 days as against last year's record of 65 eggs laid during a similar period. The winner was a Light Sussex pullet from overseas owned by Mr. F. H. Welch.

In order to penalize small eggs, only 80 per cent. of eggs weighing between $1\frac{1}{4}$ to 2 oz. could be counted in the final score. The standard egg of 2 oz. was the only egg to count.

A table showing the score of each bird was placed on the pen enabling the public to follow the progress of the contest. An interesting entry was a pen of Black Leghorns sent by the "Daily Mail" (Plate XXIX, fig. 2); this pen was bred from the winners of the recent "Daily Mail" National Test. The birds, however, were beaten by the Light Sussex team.

The following method of feeding was adopted :—

Morning. Grain (mixed) at 2 oz. per bird. Varied mixture of *makai* (maize), *jowar* (*Sorghum*), *geon* (wheat), *dhan* (rice with husks on), *bajra* (*P. typhoideum*).

Mid-day. Green food—lucerne or *palak* (Indian spinach)—at 2 oz. per bird.

Evening. Mash, based on 2 oz. dry per bird, composed of :

	1st month	2nd month	3rd month
Bran	4 parts	3 parts	$2\frac{1}{2}$ parts
Atta	2 ,,	2 ,,	$1\frac{1}{2}$,,
Gram flour or maize flour or crushed oats, in rotation	2 ,,	2 ,,	2 ,,
Meat (cooked) ..	2 ,,	3 ,,	4 ,,

Daily. Boiled *palak* and (or) cabbage leaves added.

Wednesday. Epsom salts added. 1 teaspoonful per 3 hens.

Sunday. Raw onion, chopped fine, added.

Cost. Average per bird per mensem R. 1-1-0 including sand for litter and grit. shell and charcoal for necessary digestive and shell production purposes.

The total laid by 80 birds amounted to 3,320 eggs. The eggs were sold to the public at an average rate of Rs. 2 per dozen, though the higher rate of Rs. 3 per dozen was received for eggs specially sent for the use of His Royal Highness the Prince of Wales during his tour. The profit made was expended in handsome cups awarded to the winners.

The following statement illustrates the performance of pullets entered for the competition.

1	2	3	4	5	6	7	8	9	10
Owner	Breed	No.	Gross weight	Aggregate number laid	Under $1\frac{1}{4}$ oz.	$1\frac{1}{4}$ oz. or under 2 oz. Laid	$1\frac{1}{4}$ oz. or under 2 oz. Proportion to count	2 oz. and over	Total of columns 8 and 9
			oz.						
Mr. F. H. Welch .. (England)	Light Sussex ..	1	$136\frac{1}{4}$	69	..	5	4·0	64	68·0
		2	$104\frac{1}{2}$	52	..	4	3·2	48	51·2
		3	121	62	..	20	16·0	42	58·0
		4	15	8	..	4	3·2	4	7·2
Mrs. Ward Jackson (England)	Austrolops ..	6	$94\frac{1}{4}$	54	1	34	27·2	19	46·2
		7	$93\frac{1}{2}$	53	..	37	29·6	16	45·6
		8	$85\frac{3}{4}$	46	..	27	21·6	19	40·6
		9	$73\frac{1}{4}$	37	1	6	4·8	30	34·8
Mr. Arthur Snowdon (England)	White Leghorn	10	$97\frac{1}{2}$	48	..	4	3·2	44	47·2
		11	19	14	5	9	7·2	0	7·2
	Ancona ..	12	$99\frac{1}{2}$	51	..	13	10·4	38	48·4
		13	$106\frac{1}{4}$	57	..	31	24·8	26	50·8
Mrs. G. J. Cowper..	Black Minorca ..	14	$88\frac{3}{4}$	43	..	2	1·6	41	42·6
	Black Leghorn	16	$101\frac{1}{2}$	51	..	3	2·4	48	50·4
		17	$121\frac{1}{4}$	61	..	2	1·6	59	60·6
Mr. L. G. Price .. (England)	White Leghorn ..	19	127	63	..	3	2·4	60	62·4
Mr. Murray Linder (England)	White Leghorn ..	20	$60\frac{3}{4}$	32	..	12	9·6	20	29·6
"The Daily Mail" (England)	Black Leghorn ..	21	83	38	..	1	0·8	37	37·8
		22	$100\frac{1}{2}$	50	..	11	8·8	39	47·8
		23	$108\frac{1}{4}$	53	..	7	5·6	46	51·6
		24	$107\frac{3}{4}$	57	..	24	19·2	33	52·2

1	2	3	4	5	6	7	8	9	10
						1¼ oz. or under 2 oz.			
Owner	Breed	No.	Gross weight	Aggregate number laid	Under 1¼ oz.	Laid	Proportion to count	2 oz. and over	Total of columns 8 and 9
Mr. Brown ..	Light Sussex ..	32	109	54	..	3	2·4	51	53·4
		33	108½	51	..	0	0·0	51	51·0
		34	46¾	23	..	1	0·8	22	22·8
		35	122½	63	..	19	15·2	44	59·2
Mr. A. C. Bullmore	White Wyandotte,	36	110½	60	..	2	1·6	58	59·6
		37	100	54	..	25	20·0	29	49·0
	White Leghorn	38	95¼	46	..	1	0·8	45	45·8
		39	98¼	47	..	0	0·0	47	47·0
Mrs. Johnson ..	Black Minorca	43	64¾	32	..	1	0·8	31	31·8
	White Leghorn	44	78½	37	..	1	0·8	36	36·8
		45	41	20	..	0	0·0	20	20·0
	Black Leghorn	46	125¼	64	..	11	8·8	53	61·8
Mr. B. K. Mitra ..	White Leghorn	47	55¾	29	..	10	8·0	19	27·0
		48	98¼	55	..	41	32·8	14	46·8
Mrs. Lane ..	Black Leghorn ..	52	92½	51	..	35	28·0	16	44·0
		53	35½	17	..	3	2·4	14	16·4
		54	86¼	41	..	4	3·2	37	40·2
Etah Mission Farm	White Leghorn ..	55	59¾	31	..	16	12·8	15	27·8
		56	78½	39	..	3	2·4	36	38·4
		57	95½	47	..	2	1·6	45	46·6
		58	95½	51	..	26	20·8	25	45·8
Mrs. Duncan ..	White Leghorn ..	59	41	20	..	2	1·6	18	19·6
		60	92½	43	..	2	1·6	41	42·6
		61	12½	6	..	0	0·0	6	6·0
		62	44¾	23	..	6	4·8	17	21·8
Capt. Mayo ..	White Leghorn ..	63	111¼	55	..	6	4·8	49	53·8
		64	109¼	58	..	27	21·6	31	52·6
		65	111½	54	..	0	0·0	54	54·0
		66	116½	60	..	15	12·0	45	57·0
Mr. J. H. Luke ..	Rhode Island Red	71	109	56	..	9	7·2	47	54·2
		72	91¾	48	..	20	16·0	28	44·0
		73	112	52	..	2	1·6	50	51·6
		74	70¾	34	..	5	4·0	29	33·0
Mr. B. R. Splane..	Black Minorca ..	75	97	45	..	2	1·6	43	44·6
		76	53¼	25	..	0	0·0	25	25·0
		77	90	41	..	1	0·8	40	40·8
		78	32¾	17	..	6	4·8	11	15·8
Mrs. Lambert ..	White Leghorn	79	99¾	52	..	14	11·2	38	49·2
	White Orpington	80	80¾	41	..	9	7·2	32	39·2
Mrs. Ricketts ..	White Leghorn .	81	63¾	33	..	15	12·0	18	30·0
		82	26	13	..	3	2·4	10	12·4
		83	47¼	26	..	16	12·4	10	22·4
		84	40½	21	..	6	4·8	15	19·8

1	2	3	4	5	6	7	8	9	10
						$1\frac{1}{2}$ oz. or under 2 oz.			
Owner	Breed	No.	Gross weight	Aggregate number laid	Under $1\frac{1}{2}$ oz.	Laid	Proportion to count	2 oz. and over	Total of columns 8 and 9
Mr. A. E. Slater ..	Black Leghorn	91	16	8	..	3	2·4	5	7·4
		92	108	50	..	0	0·0	50	50·0
Mrs. Denning ..	White Leghorn	101	97¾	47	..	1	0·8	46	46·8
		102	79¼	35	..	1	0·8	34	34·8
Court of Wards, Sitapur ..	Black Minorca	108	100¼	48	..	1	0·8	47	47·8
		109	67¼	31	..	1	0·8	30	30·8
	Black Leghorn	110	96½	49	..	5	4·0	44	48·0
		111	102½	46	..	0	0·0	46	46·0
U. P. Poultry Association ..	White Leghorn	112	50	25	..	2	1·6	23	24·6
		113	57½	27	..	1	0·8	26	26·8
	Black Orpington	114	113	54	..	0	0·0	54	54·0
	R. I. Red	115	114½	54	..	0	0·0	54	54·0
Civil Veterinary Department, Lucknow ..	White Leghorn	116	84¾	37	..	0	0·0	37	37·0
		117	68¼	31	..	0	0·0	31	31·0
		118	65¼	31	..	1	0·8	30	30·8
		119	29¾	13	..	0	0·0	13	13·0

LIST OF SPECIAL PRIZE WINNERS AT THE COMPETITION.

	Prize	Winner
1	Cup for the best layer of largest number of eggs, presented by H. E. the Governor, United Provinces.	Mr. F. H. Welch's (England) Light Sussex pullet, laying 69 eggs.
2	Cup for the best layer of largest number of eggs, irrespective of weight, presented by the U. P. Poultry Association.	Ditto.
3	Cup for the best layer from overseas, presented by the Stewards of Lucknow Races.	Ditto.
4	Cup for the best layer of two-ounce eggs owned by a member of the Indian Poultry Club, presented by the Indian Poultry Club.	Mrs. G. J. Cowper's (Rajputana) Black Leghorn pullet, laying 61 eggs, 59 weighing each 2 oz. or over.
5	Cup for the best layer from India, presented by the Stewards of Lucknow Races.	Mrs. K. Johnson's (Lucknow) Brown Leghorn pullet, laying 64 eggs.
6	Cup for the best team of four birds entered, presented by the U. P. Poultry Association.	Capt. Mayo's (Nahan, Sirmoor States) White Leghorn pullets, laying respectively 55, 58, 54 and 60, totalling 227 eggs.
7	Cup for the best layer owned by a resident of United Provinces, presented by the U. P. Poultry Association.	Mrs. K. Johnson's (Lucknow) Brown Leghorn pullet, laying 64 eggs.

	Prize	Winner
8	Cup for the best layer owned by an Indian resident of the United Provinces, presented by the U. P. Poultry Association.	Mr. B. K. Mitra's (Lucknow) White Leghorn pullet, laying 55 eggs.
9	Cup for the best layer from the stock bred or purchased from the U. P. Poultry Association, presented by the U. P. Poultry Association.	Capt. Mayo's (Nahan, Sirmoor States) White Leghorn pullet, laying 60 eggs.
10	Cup for the best White Leghorn layer, presented by the U. P. Poultry Association.	Mr. L. G. Price's (England) White Leghorn pullet, laying 63 eggs.
11	Cup for the best layer of any other light variety, presented by Messrs. Perry & Co., Lucknow.	Mrs. K. Johnson's (Lucknow) Brown Leghorn pullet, laying 64 eggs.
12	Cup for the best layer of any heavy breed, presented by the U. P. Poultry Association.	Mr. F. H. Welch's (England) Light Sussex pullet, laying 69 eggs.

Selected Articles

THE CATTLE QUESTION IN INDIA.*

BY

LIEUT.-COL. J. MATSON

Assistant Controller of Military Farms

I.

THIS matter has of late attracted a considerable, if tardy, attention. There is growing popular anxiety as to the sufficiency of the stock of cattle. Unfortunately there is much misconception as to the actual facts ; few have a practical knowledge of the subject ; fewer still a knowledge which goes beyond the borders of the province in which they reside. Moreover, many of those who have interested themselves in the subject have approached it with preconceived ideas based on erroneous premises.

In these circumstances it seems desirable to have a clear examination of the question and a frank statement of the facts and, where the facts disclose unsatisfactory conditions, of the causes of such conditions. We must then consider the possible measures of cure in the special conditions obtaining in India.

The first thing to notice is that, contrary to widespread belief, there is no shortage of cattle. Whether the number present in India just now is greater or less than a decade earlier one cannot tell, nor is it of any importance. The simple truth is that India is grievously over-stocked with cattle, and it must be many years since it reached the limit of its natural carrying capacity in

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this respect, since when any rise or fall in the numbers will be due to the variations in seasons and consequently in food-supply.

A comparison with the United States.

For the sake of those who think that India needs more cattle one may invite a comparison with the United States of America. The statistics for both countries are illuminating. India, with an area of 1,766,000 square miles, has 174,757,422 bovine cattle, 2,114,400 horses and 2,449,417 mules, donkeys and camels, making a total of 179,321,239, which is equal to 101·5 per square mile. These figures include Burma, and, apart from some Indian States, relate to the year 1920. The United States of America, with an area of 2,970,138 square miles, possesses 67,866,000 bovine cattle, 21,534,000 horses and 3,404,000 mules, a total of 92,804,000, equivalent to 31·2 to the square mile. In this area Alaska and foreign possessions, as well as water, are not included, and the figures relate to the period after the war except as regards mules. Horses and other draught animals are included in both cases as Indian cattle are largely used for draught purposes.

From these figures we see that India, with little more than half the area, has almost double the number of animals used for draught and milk production ; if we consider further that of the United States cattle some two-thirds are kept solely for meat, whereas in India the proportion is fractional, the difference in the figures is still more striking. Again, whereas a square mile in the United States supports milk or meat-producing or draught animals to the number of 31·2, in India it supports 101·5.

India's remarkable position.

Perhaps the contention will be more convincing if stated in another way. Imagine the case of a man who purchased an uninhabited island and turned loose on it cattle of both sexes. They would breed and multiply until the number equalled that which could be supported by the available food. Thereafter the whole would always be in poor average condition and would tend to breed less frequently : the rate of increase going up with good seasons and

going down, with great mortality from starvation, in a succession of poor seasons. On an average of years there could be no further increase in numbers.

India is in exactly the position of such an island. There is no off-take of the natural increase of stock across the land frontier, nor, owing to the habits and customs of the vast majority of her people, is there appreciable reduction by slaughter. A certain number of cattle are killed for meat in the North-West, and this takes some of the surplus from the district adjoining, but this number, added to the small number of animals slaughtered in a few large cities and cantonments, cannot have an appreciable effect on the number which represents the natural increase from a parent stock of 174 millions of cattle. In such circumstances the proposition that the cattle population of India must long ago have reached the point at which further increase is stopped by limitations of food-supply, aided by the ravages of disease, is incontestable.

Pursuing this line of thought to its logical end some startling conclusions are inevitable. The tolerance extended to the activities of the cattle poisoner in times of fodder scarcity is explained; while measures designed to protect cattle against disease, where such aid is not restricted to the valuable animals, may be actually harmful from an economic point of view. It may even be stated without serious exaggeration that the cattle population in the end compete with human beings for the available supply of food. Moreover, over-stocking results in such deterioration of the quality and value of the animals in general that by action and reaction the cattle owner in India is unable to attain in the country the food on which his cattle could be kept alive in the time of famine, because the cattle owner in Europe, whose animals are more highly productive, can afford to outbid him.

Low yield of milk.

Yet another result of the low yielding capacity of the cattle is that the cultivator is impelled to keep still more animals. He has cows whose male calves are reared for the plough, and separately

buffaloes, whose milk, *ghi*, etc., produce a part of his income. To combine both functions in one and halve the fodder bill is impossible in the present state of affairs. When one considers the density of population on her productive areas it is obvious that India cannot feed 174 millions of cattle in addition to 300 millions of human beings and give all a sufficiency. The important thing, therefore, is not whether there are many or few cattle, but whether useful classes of cattle are sufficient or insufficient. Cattle in India have, for practical purposes, two uses only, draught and milk. As regards draught cattle the number existing is sufficient, though their draught power is far short of requirements on the average. In some quarters there are complaints that there must be an insufficiency of numbers because prices have risen. That does not follow. The natural consequence of a general rise in the prices of the foods consumed by animals is a rise in the price of those animals, but any rise that has taken place in prices of draught oxen in recent years is all to the good. The man who breeds and rears a draught bullock still receives a wholly inadequate return for the food that the animal has consumed up to maturity. Moreover, the cultivator who buys a bullock to-day is a seller to-morrow, so that he is not hurt by a rise in prices. The cause of the deficiency in draught power is simply the over-stocking already referred to, resulting in insufficient food for all and inferior development of thousands in consequence; when large numbers die in a famine there may be a local shortage in numbers just after, but it is purely temporary.

Cause of the milk shortage.

When we come to the other function of cattle, namely, production of milk, the position is very serious, indeed. In India there are probably 60 millions of adult female bovine stock, yet of these a very small proportion contribute anything to the milk supply of the human population. That supply is drawn only from the animals which give more than enough milk to support their own offspring. There are no statistics available to show what the proportion of such animals is, but a very slight acquaintance with the general character of Indian cattle will tell one that it must be

very small, indeed. The appalling shortage of milk in the cities is, indeed, the clearest proof of deficiency of milk cattle, though cattle swarm. Bad as the position is now, however, it would not be so disquieting were it not that the evidence points to a very much worse state of affairs in the future.

Fifteen to twenty years ago milk was cheap and was in sufficient supply for the demand, but that demand was small through the poverty of the lower, middle and the labouring classes. Milk enters so largely into the diet of the well-to-do Indian that any increase in average wealth was bound to be followed by an increase in the consumption of milk if the demand could be satisfied. Such increase in the wealth there has been. One cannot assert that consumption of milk has increased accordingly, but it is certain that many more people would now consume milk, or more of it if the supply were sufficient. That is too often quite impossible. There must be thousands of Indian children at this moment whose parents need milk for them and are willing to pay a price which would return a good profit if the dairy industry were even moderately well organized, yet cannot get it of fair standard of quality. The shortage is so great that available supply meets the demand only after a degree of adulteration in the hands of the distributors which practically cancels its value ; at the same time the price of "market" milk has risen to a point at which the pure milk contained in it sells at almost incredible rates in some cities. The large demand and higher prices ruling should have induced the required increase in supply, but they have not. Why ? The proximate cause is that the districts which breed them no longer put out a sufficient number of good dairy cattle to meet the demand.

THE SUPPLY OF CATTLE.

Fifteen to twenty years ago the cattle required for urban dairies were mainly obtained from the Punjab. Large numbers of Sanhiwal cows could be bought in Amritsar, and equally large numbers of the local breed from Hariana, at very moderate prices. The supply from both these sources has practically dried up now. In Sind there is still a certain supply of cows available, but it is all

too small to meet the demand. In consequence of these changes many more buffaloes are now used for town-dairying and in turn the good breeds of these animals are proving unable to meet the demand. In 1911 the writer bought some 1,500 milch buffaloes in about three months from the country round Rohtak, Hissar and Fazilka at an average price in the neighbourhood of Rs. 100. In recent times five or six hundred would have been the limit obtainable with similar efforts, while the price has risen to between Rs. 250 and Rs. 300.

One serious aspect of the case, now that the number demanded are greater than on-coming supply can furnish, lies in the peculiar character of Indian dairying which makes it so wasteful. The breeding grounds are far removed from most of the cities, and no cow is exported without her calf. She never returns, nor does her calf, and she milks for one period only and does not breed again in the city *gowallas*' hands, so has to be replaced annually.

This wastage would not matter if the parent stock were sufficient, but it is not. The exporting districts, with plenty of cattle, have a diminishing number of the milking class. Here we encounter another peculiar Indian feature. The export is entirely of the best cattle, but there is no compensating wastage of the inferior stock. These are retained in increasing numbers and breed unchecked, and the result can only be to lower the average quality.

II.

The previous article stated the facts in regard to the cattle and milk question and outlined the causes of the ills that exist. To suggest any effective cure is a matter of the greatest difficulty, but enough and to spare has been written condemning the existing state of affairs. What is now wanted is a constructive policy.

It would be useless to stop export, as is so often suggested. On the contrary, in a country where the stock of cattle is excessive, it should receive every encouragement. Export trade enhances values, and the breeders are encouraged to feed their stock well and to breed the best, and this tends to raise the quality of all the stock in the country. This is subject to one qualification in the matter

of export beyond India, namely, it is possible that restriction on export of females would tend to a more lasting and profitable trade in the long run.

Improvement of breeds essential.

The real need of the situation is obvious, namely, such an improvement in the local breeds of cattle that the same animal will produce milk for sale or consumption by her owner and a calf fit to take its place in plough or cart in due course. Further, the yield of milk must be such that the cow is a profit-earning machine when kept for milk alone. But, and here is the difficulty, it is useless to embark on any widespread schemes for improving local breeds, by importation or otherwise, unless or until the food supply is made adequate to the requirements of such an improved breed. The improved dairy cow needs an extra large food-supply and must get it with the least possible exertion. She is consequently the first to succumb to disease when underfed, and the first to die when actual starvation reigns. In other words, survival of the fittest to withstand starvation means survival of the least fit to give milk.

To suggest any short cut to an adequate food-supply is impossible. It can come about by reduction in numbers or by increase in production, both exceedingly difficult to bring about. Reduction in numbers would come if checks could be placed on breeding; if, for instance, only selected males were kept and only approved females allowed access to them. It is understood that certain advanced village co-operative societies in Northern India already have a scheme which goes some way towards this. Unrestricted breeding of the unfit is certainly a very great evil at present. So long as it continues vast numbers of cattle are under sentence of death by starvation from the very moment of birth. It is a point deserving the anxious consideration of every one whose inclination, religious or otherwise, is towards protection of the cow.

Insanitary milk-supply.

Turning more particularly to the milk question in cities, it is unfortunate that the attention hitherto given to the supply has been almost entirely confined to sanitary improvement. The

milk-supply of India is undoubtedly insanitary, in this respect it is probably the worst in the world or certainly as bad as can be found anywhere. But improved sanitation offers no hope without a very great increase in the quantity of milk. No number of laws, nor armies of inspectors, will obtain for any city, for long, a pure and sanitary supply of milk if the quantity available is seriously inadequate. The first desideratum is that all the people of a city should have milk available at a reasonable price. It is useless to provide a sanitary and wholesome supply which can be purchased only by the richest third or quarter of the population. Moreover, in the sanitary aspect, it may be remarked that Indians consume milk in a cooked form, so that insanitary conditions surrounding the production are much less dangerous to them than to Europeans. On the other hand, they need their milk pure.

Most of the ameliorative schemes propounded hitherto have been defective in that they have not increased the available supply. They have usually amounted to taking part of the existing supply out of the hands of certain people and putting it into the hands of others. Granted that in the hands of others the supply would reach the purchaser pure. With insufficiency prices must rise, so that before long one would find that the purchaser of this milk would be a dealer and the milk would be passed on to the poorer people, no longer pure, as before. Further, no scheme yet seen has gone to the root of the matter, in the direction of reducing the cost of production, on a sufficiently large scale.

At present the milk-supply of Indian cities is produced in the suburbs, or within a few miles of the outskirts, and, broadly speaking, every animal is stall-fed. In such circumstances cheap milk will never be produced. We therefore require (*a*) a large increase in the supply, which does not mean merely the purchase of more cattle and bringing them to the environs of a city, but an increase in the quantity produced in the country: (*b*) milk produced more cheaply. To produce more milk we must improve the breed by selection and the usual methods of successful cattle breeders, and, at the same time, provide a copious supply of food to enable the improved animal to function as such. To produce cheap milk we must

provide the milch animal with cheap food suited to her, that is to say, nutritious and succulent fodders, and we must locate the cow at the place where these are found.

THE QUESTION OF CHEAP MILK.

On the subject of cheap milk it may be noted that there are two methods by which it is produced; one is where climatic and soil conditions are such that the cattle can live on pasture practically the year round. Few places in the world have such conditions, and none of the examples can be reproduced in India. Next to rich pastures in a temperate and humid climate, the cheapest milk is produced where dairy farming is combined to a certain extent with other forms of agriculture, by which the food-supply of the cattle is partly obtained in the form of by-products of saleable crops whose production in turn is rendered more profitable by the supply of manure. Also, there is the advantage that all the farmers' eggs are not in one basket.

This system is susceptible of being extended and improved in India where it already exists. The Punjab peasants who breed the best buffaloes are engaged in what is really dairy and mixed farming. We have only to transplant (and intensify somewhat on the dairy side) the agriculture of Hariana to the vicinity of the cities and to provide rapid transit and the other usual features of a transported milk-supply and the problem should be solved. The present difficulty is that there are no large holdings in the vicinity of cities which can be devoted by their owners to this form of dairy farming.

It is because of this difficulty that it appears to the writer that municipal or State aid will be needed before anything effective can be done. Granted municipal aid, taking the form of acquisition, compulsorily or otherwise, of a tract of land in the vicinity of a city, yet outside the area of suburban values, then the plan sketched below appears to be workable.

WHAT MIGHT BE DONE.

It is a method which has been extensively used, though called forth by somewhat different circumstances, in the United States

and in Australasia where there are several examples of comparatively large estates whose owners have cut them up into dairy farms, have built dwellings for the people, and buildings for the animals on each, and have then employed tenants on special agreements to work each farm, the resulting milk being sold for the joint profit of estate owner and tenant, or sometimes sold direct by the tenant to the estate owner.

Such schemes have many variations in matters of detail. In some the estate owner has provided everything, livestock, implements and utensils, in addition to land and buildings. In others the tenant has brought his own herd of cattle, or has shared the cost of purchasing cattle; but in all there is one main feature, namely, that a capitalist provides the bulk of the capital, yet the tenant is independent within wide limits and has reward and profit in proportion to his own diligence and efficiency.

The scheme, as imagined, if any Indian Municipality did take it up, would be somewhat as follows:—After acquiring, say, 5,000 acres of land the Municipality would cut it up into holdings of 25 acres, would erect on each, or in central clusters, dwellings for the tenants and others for their assistants and for stock. At the same time, it would provide all necessary facilities of general conveyance and utility, such as water-supply and roads. Next, it would invite cultivators accustomed to keeping cattle to become tenants of these holdings, as dairy farmers primarily, but unrestricted as to the nature of the mixed farming added to the dairying so long as the head of milch stock was carried and adequate provision made in the cultivating plan for their maintenance in normal season. The Municipality could finance the purchases of the milch stock, or would very likely find that tenants with a sufficient capital to purchase these on their own account would be forthcoming, or a combination of the two could be made. Similarly as to the plough-cattle and implements.

A PLAN FOR RECOUPMENT.

If the Colonial and American methods were followed no cash rent would be charged, but the Municipality would be recouped

from a proportion of the sale proceeds (*a*) of the milk, (*b*) of the increase in stock, (*c*) of the various forms of produce that would be sold off the land. A cash rent is practicable as an alternative if desired. The general plan of working the holdings is laid down within which the tenant can vary his work in matters of detail, but the broad essentials are that each holding is devoted primarily to maintaining its milch cattle and their increase for a short time, and that anything sold off the land is a by-product of that, and not *vice versâ*.

The Municipality would also provide the organization for collecting from the tenants the diurnal output of milk and conveying it to the city. It would have to decide whether it would purchase the milk from tenants itself, in which case sale to the Municipality should not be compulsory, though it is practically certain that no competitor could offer an equal price, as no competitor would have the organization for carrying the milk in good condition to the city. Or the Municipality could simply convey the milk to the city levying a charge per maund and there sell it, sharing in the proceeds.

In practice many special features would need to be introduced to suit the peculiar conditions of the country and the idiosyncrasies of the people who would work the scheme, while many things apparently necessary at the beginning would later be found not so. The writer believes that such a plan would work well provided practical men were entrusted with its inauguration and control.

The main value of such a municipal estate would be demonstrative. If the tenants were well-to-do it might reasonably be hoped that intelligent dairy-farming would spread to the occupiers of surrounding lands, and their produce would swell the municipal supply (as offering the best market) and they would be buyers of improved stock. The Municipality would not risk much. The land would always be a saleable asset, or it could be let profitably to present suburban cow-keepers.

That is the first suggestion, and it is designed to assist the municipal authority in establishing a better milk-supply, but its special advantages are first that it adds to the national supply of milk; secondly, that it reduces the cost of production, in that the

cattle are fed more cheaply and more naturally which means a larger yield, and that they last several years instead of one only. Lastly, they would cost nothing for transit from distant breeding grounds and would not suffer the great damage and loss involved in being carried for days on end in iron boxes, miscalled cattle wagons, by slow trains in a blazing sun.

Government co-operation.

A second suggestion, designed to have more widespread effect in the long run, is that the Governments of the provinces in which the old dairy cattle breeding districts are situated should do something more to preserve and improve both the milking and draught qualities of the local breeds. We have already seen that this must be accompanied by measures designed to provide for the adequate feeding of the improved stock. Fortunately in the Punjab, where three of the breeding grounds, and those formerly the most important and productive ones, are found, the Government has large areas of unsettled irrigable land and will have more as various canal projects are brought into being. In Sind, also, we may suppose that the Government has areas of land not as yet productive, and that the Sukkur Barrage project will bring many of these to a condition in which they will feed cattle.

The idea is that the Governments should forthwith set about placing special bulls at stud in the recognized breeding districts—the Central Punjab, Sind, Hariana and Gujarat. These special bulls should serve only approved cows, and the Government should guarantee to purchase every well-grown female calf sired by them at a price to be stated beforehand, which would be above the present market value of a calf of that age.

Such calves would be collected on Government farms to be established, mated there with selected bulls at the suitable age and sold, on calving, at periodical auction sales.

How the scheme would work.

It is contemplated that, in the first instance, Government would incur a small loss, but that gradually the worth of the cows

reared would prove itself and the prices realized at auction would rise, and that presently it would be found that breeders of the calves sired by Government dairy bulls would no longer be content to accept the Government price as they would get more from other buyers desirous of rearing them for sale as cows later, whereupon Government would drop out of the rearing part of the scheme and confine its efforts to supplying selected bulls until in turn these came forward, of the quality required, from private breeders.

This seems the only way of re-developing the valuable Sanhiwal breed, of which there are still many crosses in the hands of the cultivators in the Lower Bari Doab, or to resuscitate the milking strains of the Hariana cattle. The serious difficulty is that time is short, and some of the breeds are so near to extinction that what is to be done needs doing quickly.

In making the above suggestions the writer is fully conscious of the many difficulties that can be alleged to stand in the way of their successful adoption, but he does not think any of these difficulties are insuperable, and, broadly speaking, he suggests nothing that he has not personally tested in India or elsewhere. Whatever difficulties there are, the question really is this, what other system or plan can be suggested which is likely to have any influence on the milk-supply of the country at large, or on any considerable portion of it, within a measurable distance of time, if ever? The matter is urgent and pressing, it has more importance for the majority of the people than many avenues of agricultural development which have been fairly well explored in recent times. The newly-awakened interest in infant welfare, to mention only one aspect of the case, cannot achieve great success without a sufficient supply of pure milk.

FUTURE OF WORLD'S COTTON SUPPLY.*

SHORT-SIGHTED POLICY OF MANUFACTURERS: GROWER AND USER ARE REALLY PARTS OF ONE INDUSTRY.

BY

SIR CHARLES W. MACARA, BART.,
Founder of International Federation of Master Cotton Spinners and Manufacturers' Association, Manchester.

IN a letter I have received from my esteemed friend, Mr. Harvie Jordan, Secretary of the American Cotton Association, dealing with the present unsatisfactory condition of things in the cotton-growing area of the Southern States, I find a request that I should "express the attitude of the spinning industry regarding the payment of a price for cotton that will enable growers to produce the staple on a basis cost, plus a reasonable profit."

I should be very glad indeed to be able to do so, but unfortunately I do not yet find that enlightened opinion abroad which will allow me to say that the cotton trade has begun to view our supremely important industry in a comprehensive way—that it has begun to take into account not merely the question and cost of the production of yarn and cloth, but how it must insure for the future a full and in every way adequate supply of the raw material.

It is an extraordinary thing how indifferent the people engaged in the manufacture of cotton are to their welfare in this matter. On this question in particular I have for very many years, but more especially since the war, carried on a large propaganda work, and I have never ceased to put before the spinners of the world the absolute necessity of seeing that a price is paid to the grower of cotton that will remunerate him for his labours and enterprise.

* Reprinted from *Textile World*, LXI, no. 24.

SUPPLY OF FIRST CONCERN.

How is it possible to secure present and future supplies otherwise? One would think that it would be the first concern of anyone engaged in business to see that his raw material was placed beyond the possibility of doubt, but somehow those who spin and manufacture cotton seem to have little or no anxiety as to the supplies upon which the whole of their existence depends. Possibly the regularity with which cotton has year by year come to hand when required has lulled them into a sense of security, or may be the fact that most of the raw material is grown so far away from the places where it is manufactured induces a feeling of unconcern.

At all events, this fatal indifference or inertia exists and I see nothing but some great upheaval that is likely to bring people to their senses. Some day the desire to obtain cotton at under cost price will result in a condition of things such as we had in the sixties of the last century, and again in 1903-04 when the Lancashire mills and those of the rest of Europe had for twelve months to curtail their production by one-third, and employers had to play Providence to their workpeople by spreading wages over the whole of the twelve months, instead of paying full wages for eight months and none at all for four. Then, perhaps, even the most selfish and short-sighted will begin to take notice.

What has been my object all along is to wake up our people in time, and to make them see what a catastrophe it would be both for themselves and the world in general if the wherewithal for our most important manufacturing industry was not forthcoming.

A SERIOUS SITUATION.

I am by nature neither a pessimist nor an alarmist, but the state of things existing in the cotton fields of America at the present time must give rise to the gravest anxiety in the mind of anyone who has the welfare of his trade and his fellowmen at heart. Mr. Jordan, whose word can be relied upon entirely, tells a story of what he has seen on a personal tour of the cotton-producing States that is calculated to bring not only British spinners, but those of every other cotton manufacturing country, to a vivid realization of the

position of things. Not only is the boll weevil menace a terrible reality, but the result of the drastic deflation in the market value of staple farm products has brought farmers in the South to the verge of ruin.

The losses of the two crops of cotton produced in 1920 and 1921 are conservatively estimated at $2,300,000,000, and on the top of this, thousands of negro tenants, share-croppers and labourers are leaving the cotton fields and moving to industrial centres as a result of their inability to cope with the changed conditions resulting from the cotton boll weevil menace. Indeed, the whole situation is changing in the Southern States, and if capital and labour are not forthcoming for a more intensive and naturally more costly system of cultivation the outlook is black indeed.

Must cover production cost.

"Our efforts are to produce the crops as economically as possible," says Mr. Jordan, "but it cannot be sold for less than the cost of production and the industry maintained in this country."

These are serious and weighty words, and ought to go home to every cotton spinner and manufacturer in the world. For the question arises, if America is obliged to go out of business as a cotton producer, where is the world in future to get its supplies?

It is clear, therefore, that we shall have, by hook or by crook, to get the spinners and manufacturers of the world to view this industry of cotton on comprehensive rather than on sectional lines: factory owners will have to be made to see that it is no use whatever to gloat over advantages gained to the detriment of the planters, and that they are only pursuing a foolish and suicidal policy to expect to make profits themselves while the planters make losses. It simply means that this stupid way of doing business will ultimately result in the planter going out of business, leaving the spinner and manufacturer stranded high and dry. The planter will have to come to be regarded as of the same importance as any other person who touches cotton on its way to the draper's counter, and his profits and rewards will have to be considered just as much as either spinner, manufacturer, finisher, merchant, middleman, or

shipper. All are indispensable to the production of the finished article, and all must be sufficiently compensated for the work they do.

It is amazing that the planter is so little regarded, seeing that he is the basis of everything. If cotton could not be got, then none of us would be wanted. What I have always contended in the numerous articles and books I have published, out of an unrivalled experience of the cotton trade all over the world, is that we must regard cotton production and manufacture as one whole industry, and that we should always put in the forefront the proper remuneration of the cotton planter. The planter, of course, should be encouraged to avail himself of all modern appliances, scientific methods, and inventions, and to cultivate his land economically and to the greatest advantage, but when he has done this his enterprise should be fully acknowledged and appreciated. Especially should consideration be given at a time like the present, when the work of the planter is not only very costly but surrounded by extraordinary difficulty.

More intensive cultivation.

I should like very much to see something done to intensify cultivation, believing as I do that it would be no difficult thing to double the yield of cotton in the fields of the Southern States of America. During my visit to Atlanta in 1907, I was presented with a case of cotton bolls of a description which it was estimated would have produced four bales from an acre. The average at that time was a third of a bale per acre, and it is probably less to-day. I quite admit that these bolls were exceptional, but they were an example of what can be done.

I am inundated with correspondence from people who have read my articles on this and kindred questions which have appeared in British and American journals, and some of the writers have an idea that I personally can take over the whole of the cotton crop and deal with it. This, of course, is what no one man can do, but I shall never cease to try to educate the trade up to its duties and obligations in this matter of remunerating the cotton planter.

How thoughtless and illogical are some of the men on the manufacturing side can be gathered by their attitude towards the British Cotton Growing Association. While they constantly show a total indifference as to whether the cotton they secure will pay for the growing, they show dissatisfaction when the scale of developments in cotton growing is below expectation.

I have been uneasy about the cotton situation for long enough. Had my advice been taken at the outbreak of the war, cotton would have been withheld from enemy countries and the war shortened by a good twelve months; and again had a reserve of cotton been formed of the large surplus which existed at that time, we should not have had the price falling to 4*d.* a pound owing to the glut, nor should we have seen identically the same cotton run up to 45*d.* a pound later on, and all the consequent chaos caused by prices of clothing soaring sky-high and then being rushed down by an artificial and disastrous campaign of slump.

It was my misfortune, however, to be defeated by the folly of the Government and the stupidity of the English Cotton Spinners' Federation, the members of which thought of nothing beyond the immediate advantage of procuring a quantity of cheap cotton, and never paused to think that the planter might retaliate by reducing his acreage under cultivation and making them regret their cupidity later on. The whole thing was a frightful mistake, and cost the country dear in a two years' trade depression from which we are only just now emerging.

My American friends, however, may rest assured that I shall continue to work whole-heartedly for a recognition of the full status of the planter, believing as I do that it is not only to his own but to everybody's interest in the cotton trade that his claims should have first consideration.

Notes

A SOURCE OF ERROR IN POT CULTURE EXPERIMENTS.

Most workers in Soil Science make use at one time or another of pot cultures. It can be confidently asserted that the universal experience of their use leads to the inevitable conclusion that the method is full of difficulties which limit the reliability of conclusions drawn from the results obtained, not only in a quantitative sense but also in a qualitative one. There is nothing new in this conclusion but the writer has lately had experience of what may be to many a novel and unsuspected source of error in pot culture experiments, and this note is intended to point it out for the benefit of other workers who may possibly be unaware of its existence, or at any rate of the degree to which it may affect their results.

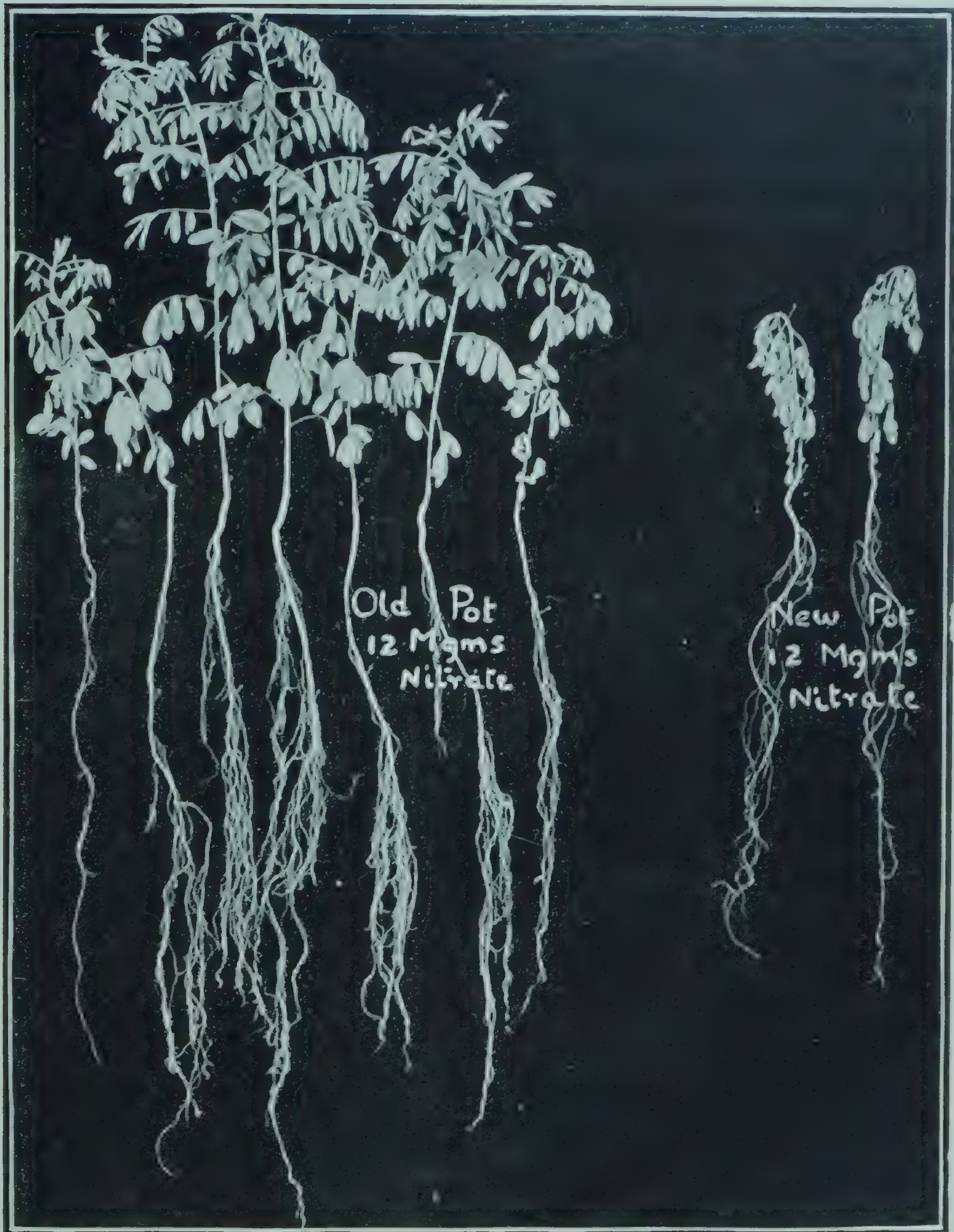
In this laboratory pot cultures are carried out in circular earthenware pots, glazed inside and out, 10 inches internal diameter and 12 inches in depth, the walls being about one inch thick, with a drainage hole one inch in diameter at the bottom on one side. In December 1921, an experiment was started to determine the effect of varying soil concentrations of nitrate upon the formation of the root nodules of indigo ; this involved the use of sixty-four pots in all, with eight pots in each series and different concentrations of nitrate, the latter varying from 3 mg. up to 12 mg. per 100 grm. soil. In this experiment some of the pots were new but most of them were several years old, the former fortunately being conspicuous and recognizable by the yellow colour of the glaze. It was very soon noticed that growth was less vigorous in the 12 mg. pots than in the others, and shortly after it became apparent that this effect was more strongly marked in the new pots than

in the old ones. Fortunately there were both new and old pots in nearly all of each series, and the discrepancy between them became more marked and obvious as time went on. At the time of writing (20th April) the plants are seventeen weeks old and as will be seen from the photographs (Plate XXX), they exhibit differences of development both above and below ground of a very high order. It must also be explained that in the photograph showing the root development, the two miserable specimens on the right were the only survivors in the new pot receiving 12 mg. nitrate, out of 16 original seedlings, whereas 7 made fair growth in the old pot with the same treatment. The relative growth in varying concentrations of nitrate will be seen in the other photograph, as also the effect of the old and new pots respectively.

As soon as this effect became obvious an examination of other pots was made, and the conclusion arrived at was that the causative difference described above between new and old pots was one of relative porosity ; in the old pots disintegration and weathering of the glaze had taken place rendering them relatively permeable as compared with the new ones. This conclusion was arrived at both by simple measurement of the relative rates of loss of water from old and new pots when allowed to stand after partially filling with water, and by observation of the fact that salts dissolved in the water were deposited by evaporation on the outer surfaces of the old pots but not on those of the new ones.

Thus, in the old pots used in the experiment, outward water movement through the walls carried off some of the excess of nitrate, and so reduced the concentration of this salt in the soil sufficiently to allow of a certain amount of growth ; in the new pots, however, the impervious walls prevented any such movement of the soil moisture and the retention of the original concentration of nitrate resulted in the reduced growth shown in the photographs.

It will easily be understood that in such experiments this important factor might come into operation without its presence being realized ; in the case above described it was not only the very obvious differences observed, but their coincidence with equally obvious divisions of age between the pots in use that drew attention



INDIGO PLANTS IN OLD AND NEW POTS.

to the existence of this important differentiating factor. It should be stated that the old pots show no obvious signs of changes due to age nor is there any apparent deterioration in the glaze either internally or externally. It is in fact at present doubtful whether the differences in porosity between these two batches of pots may not be functions of their style of manufacture rather than of their age. In any case the observations recorded above seem to indicate the necessity of utilizing some other methods of securing non-porosity than that provided by ordinary glazing. [C. M. Hutchinson.]

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JOHNE'S DISEASE AT THE GOVERNMENT CATTLE FARM, HISSAR.

Attention was first drawn to the existence of this disease in India by Sheather,[1] who found a case on the Kathgodam road, and confirmed his clinical diagnosis by bacteriological and post-mortem examination. He remarked in his paper that this disease was probably more prevalent in India than was commonly suspected. Apart from the cases to be enumerated the writer has previously only seen one case of Johne's disease in this country. Unfortunately he was unable to confirm his clinical and bacteriological diagnosis by post-mortem examination.

Branford claims to have seen a case but the evidence is not wholly conclusive.

The existence of the disease in Bihar as reported in the Annual Report of the Muktesar Laboratory for 1919-20 is interesting.

At this season of the year (May) most of the in-calf stock on the Hissar farm is kept at the Sally farm and is fed by grazing on the oat stubble and what they can pick up on the ***bir***. During an inspection the writer noticed that four old cows showed clinical symptoms of Johne's disease. They were sent into the hospital and scrapings were taken from the rectum by Mr. T. J. Egan, M.R.C.V.S. On examination the presence of acid-fast bacilli in large number was demonstrated in rectal scrapings taken from

[1] *Agri. Jour. India,* XIII, p. 23.

two of the cows. As cow No. 181 when examined was found not to be in calf she was destroyed. Well marked lesions of Johne's disease were found throughout the intestine. A very careful examination of all the stock with which these cows had been running—some 1,500—indicated the isolation of three more cases as suspects. The bacillus could not be demonstrated in scrapings from any of the three. The only remark worthy of note, is that the diarrhœa is not nearly so profuse as in cases one meets with in Great Britain. Probably, as is the case with tuberculosis, the bacilli are not so virulent.

As this disease evidently exists in the country, the question as to what extent it exists is a matter well worth the consideration of the heads of the veterinary departments of the different provinces. If it is proved to exist to any extent, a further grave factor in the cattle problem of the country will be brought to light. As the *Agricultural Journal of India* appeals to a wide field of those interested in Indian agricultural economics, a short account of the disease is appended.

Johne's disease is a chronic bacterial enteritis. It is caused by an acid-fast bacillus which closely resembles the tubercle bacillus in morphological characters. Unlike the tubercle bacillus, however, special methods of cultivation are necessary.

The disease is characterized by rapid emaciation and a profuse watery diarrhœa. The animal gradually loses strength until it either dies or is destroyed.

Lesions are generally confined to the intestinal tract. Abortion, failure to get in calf, and diminution in milk yield are frequent complications of the disease. The disease is probably spread by the ingestion of contaminated food or water.

Early diagnosis and strict segregation are therefore essential.

Early diagnosis, slaughter and attention to disinfection of the land are the obvious preventatives. No treatment up to date has been found successful. As slaughter for the butcher would probably be received with disfavour in this country, some other method of dealing with affected animals would be necessary. [E. Sewell.]

PAPER IN CANE CULTIVATION.

THE "West India Committee Circular" publishes a summary of an interesting account of the use of paper in cane cultivation in Hawaii published in the last May issue of "Sugar." This system originated at the Oloa Plantation where the rainfall is over 100 inches per annum, and this excessive moisture necessitates much weeding and consequent labour for the hand cultivation of the young canes. It occurred to Mr. Eckhart, the Director of the Hawaiian Experiment Station, that strips of paper might be used to cover the young canes, and he accordingly commenced experiments in that direction, with the result that 3,100 acres of canes were treated in this manner last year with paper manufactured from megasse in a mill erected for the purpose on the plantation. The paper used is 30 inches wide, and weighs 142 lb. to the ream, about 1,080 lb. being required for one acre. It is surfaced with asphalt, which makes it waterproof and causes it to absorb heat, thus forcing the growth of the canes by keeping the ground warm. It is laid down on the cane rows after planting, and the young cane shoots are able to burst through the paper, which ultimately surrounds the canes and effectively keeps down weeds. It is stated that the saving of labour thus effected is not less than 50 per cent., and another important point is that the use of paper prevents "leaching" and consequent loss of soluble nitrates used as fertilizers. A further advantage is an increased yield of cane estimated last year as being not less than 10 tons per acre.

This method of treatment of the young canes is possible where scarcity of labour exists in conjunction with heavy rainfall and weed growth, and where paper of the required description can be had at such a cheap rate as to make its use economically advantageous. [KASANJI D. NAIK.]

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RESTRICTIONS ON IMPORT OF PLANTS AND SEEDS INTO INDIA.

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), and in supersession of the notification of the Government of India in the

Department of Revenue and Agriculture No. 13-C, dated the 7th November, 1917, the Governor-General in Council is pleased to issue the following order (Notification No. 580-240, dated 26th June, 1922) for the purpose of prohibiting, regulating and restricting the import into British India of the articles hereinafter specified.

1. In this order—

(*i*) " Official certificate " means a certificate granted by the proper officer or authority in the country of origin; and the officers and authorities named in the third column of the Schedule appended hereto are the proper officers and authorities to grant in the countries named in the second column the certificates required by the provisions referred to in the first column thereof;

(*ii*) " plant " means a living plant or part thereof but does not include seeds; and

(*iii*) " prescribed port " means any of the following ports, namely, Bombay, Calcutta, Dhanushkodi, Karachi, Madras, Negapatam, Rangoon and Tuticorin;

(*iv*) all provisions referring to plants or seeds shall apply also to all packing material used in packing or wrapping such plants or seeds.

2. No plant shall be imported into British India by means of the letter or sample post: provided that sugarcane for planting intended to be grown under the personal supervision of the Government Sugarcane Expert, Coimbatore, may be imported by him by such post.

3. No plants other than fruits and vegetables intended for consumption, potatoes and sugarcane shall be imported into British India by sea except after fumigation with hydrocyanic acid gas and at a prescribed port:

Provided that plants which are infested with living parasitized insects and are intended for the introduction of such parasites may be imported without such fumigation if they are accompanied by a special certificate from the Imperial Entomologist to the

Government of India that such plants are imported for the purpose of introducing such parasites.

4. Potatoes shall not be imported into British India by sea, unless they are accompanied by—

(*a*) a certificate from the consignor stating fully in what country and in what district of such country the potatoes were grown and guaranteeing that warty disease was not known to exist on the farms where the potatoes were grown; and

(*b*) an official certificate that no case of warty disease of potatoes has been known during the twelve months preceding the date of the certificate within five miles of the place where the potatoes were grown.

5. Rubber plants shall not be imported into British India by sea unless they are accompanied by an official certificate that the estate from which the plants have originated or the individual plants are free from *Fomes semitostus*, *Sphærostilbe repens* and *Fusicladium macrosporum.*

6. (1) The importation of sugarcane into British India by sea from the Fiji Islands, New Guinea, Australia or the Philippine Islands is prohibited absolutely.

(2) The importation of sugarcane into British India by sea from any other country is prohibited, unless it is accompanied by an official certificate that it has been examined and found free from cane borers, scale insects, aleurodes, root disease (any form), pine apple disease (*Thielaviopsis ethaceticus*), sereh and cane gummosis, that it was obtained from a crop which was free from mosaic disease and that the Fiji disease of sugarcane does not occur in the country of export :

Provided that in the case of canes for planting imported direct by the Government Sugarcane Expert, Coimbatore, or by Mr. G. Clarke, so long as he holds the appointment of Agricultural Chemist, United Provinces, and intended to be grown under the personal supervision of the importing officer in each case, such certificate shall be required only in respect of the freedom of the country of export from the Fiji disease of sugarcane.

7. Coffee and Hevea rubber plants shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

8. Seeds of coffee, flax, *bersim* and cotton shall not be imported by land or by sea by letter or sample post.

9. Coffee and Hevea rubber seeds shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

10. Flax seeds and *bersim* (Egyptian clover) seeds shall not be imported into British India by sea, unless the consignee produces before the Collector of Customs a licence from a Department of Agriculture in India in that behalf.

11. Cotton seeds shall not be imported by sea except after fumigation with carbon bisulphide and at a prescribed port.

12. Nothing in these rules shall be deemed to apply to any article brought by sea from one port in British India to another.

THE SCHEDULE.

[*Paragraph* 1 (*i*)].

1	2	3
Paragraph	Country of origin	Authority
4	Great Britain and Ireland ..	The Board of Agriculture and Fisheries, England.
	....	The Board of Agriculture for Scotland.
	....	The Department of Agriculture and Technical Instruction for Ireland.
	Sweden	The Ministry of Agriculture.
	Norway	The Norwegian Board of Agriculture.
	Denmark	The Ministry of Agriculture.
	France	The Ministry of Agriculture.
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	Italy	The Ministry of Agriculture.
	Kenya Colony	The Department of Agriculture.

THE SCHEDULE—*concld.*

1	2	3
Paragraph	Country of origin	Authority
	Australia	The Departments of Agriculture, Victoria, South Australia, New South Wales, Queensland, Tasmania and Western Australia.
	New Zealand	Department of Agriculture, Industries and Commerce, Wellington.
5	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States.
	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Belgian Congo	The Department of Agriculture.
	Kenya Colony	The Department of Agriculture.
	Uganda Protectorate ..	The Department of Agriculture.
	Nyassaland	The Department of Agriculture.
	South Africa	The Union of South Africa Department of Agriculture.
6	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Mauritius	The Department of Agriculture.
	Philippine Islands ..	The Bureau of Agriculture.
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	South Africa	The Union of South Africa Department of Agriculture.
	Egypt	The Ministry of Agriculture.
	West Indies	The Imperial Department of Agriculture, Barbados.
	British Guiana	The Department of Science and Agriculture.
	Trinidad . ..	The Department of Agriculture.
	Jamaica	The Department of Agriculture.
	United States	The Department of Agriculture.
	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States.
	Kenya Colony	The Department of Agriculture.
	Queensland	The Department of Agriculture and Stock.

THE LATE JOHN GARTON: WORLD-RENOWNED PLANT BREEDER.

Although it was known that Mr. John Garton had been in very delicate health for the past few weeks, his death on 15th May, 1922, at his residence, "Hafryn," Upper Colwyn Bay, came as a painful surprise to his friends and cast a gloom over the scientific world.

Mr. John Garton was born at Newton-le-Willows in March 1863, and at a very early age evinced an inquiring and scientific turn of mind, his leisure hours since his school days being devoted to scientific subjects. He was particularly absorbed in the method of reproduction of farm plants, which led in after-years to important discoveries as to how new breeds of farm plants are produced, and on which knowledge was based the now world-famous Garton system of scientific farm plant-breeding.

It is upwards of 40 years since Mr. John Garton made his great discovery, and he has the distinction of being the first scientist to apply the process of artificial cross-fertilization to cereals and other farm plants with a view to evolving new species of cereals and of combining valuable characteristics of various parental varieties. In those far-off days Mr. Garton's theories were severely criticised, but time has proved that such theories were absolutely correct and are now generally accepted.

Plant-breeding, however, did not claim the whole of Mr. Garton's attention, for he gave much thought and time to photo-micrographs, which in no small measure assisted him in demonstrating his theories respecting plant-breeding, and he possessed a unique collection of micro-photographs of reproductive organs, etc., dealing with farm plants from the germ of the seed to the plant in full growth, whilst as a bacteriologist his abilities were exceptional.

His first introduction of new breeds of farm plants took place in 1892, being a new breed of white oat, the result of a cross of "White August" and "White Swedish," the progeny of which was named "Abundance," and which remains to-day one of the most popular and extensively grown oats throughout the agricultural world.

The extraordinary success which attended the introduction of this new white oat arrested the attention of British agriculture, and the demand for his products was so great that in 1898 a company was formed to acquire the discovery of Mr. Garton, and to commercialize the products thereof, which company holds an unbroken record of successes, and is known throughout the world wherever agriculture is practised. Many are the tokens of appreciation which Mr. Garton has received, not only from the United Kingdom but also from America and the Continent of Europe. Amongst Mr. Garton's most treasured possessions were a gold medal awarded by the Highland Society of Scotland, a gold medal from the great American Exhibition held in Chicago, a gold medal from the Paris Exposition, and also a gold medal awarded by the famous Brussels Exhibition.

British agriculture owes a debt of gratitude to the late Mr. Garton, whose life (he was never in robust health) was one continuous struggle against physical disabilities, for the advancement of agriculture generally.

The Senate of Edinburgh University quite recently offered to confer the honorary degree of LL.D. on Mr. John Garton in recognition of his life's work, and this degree, had he lived, would have been conferred upon him in Edinburgh in July next.

Mr. Garton's health finally broke down in 1912, and although with indomitable courage he from time to time conferred with his brothers, Robert and Thomas, he was unable to pursue his studies. The work has since been carried on by Messrs. Robert and Thomas R. Garton, who have been associated with Mr. John Garton for many years, and who will continue to be responsible for the plant-breeding and scientific research department.

It is conceded on all hands that his great work has resulted in the enormous increased production not only of British-grown food crops but also of those in foreign countries, and many and generous have been the appreciations of his pioneer work from all parts of the globe.

On more than one occasion the Department of Agriculture of the United States have invited Mr. Garton to lecture in that

country, but pressure of his own research work in this country prevented his acceptance of such invitations. Nevertheless, he never spared himself in his efforts for the betterment of British agriculture, and was at all times a most acceptable, interesting and instructive lecturer in agricultural science throughout the United Kingdom. [*The Examiner*, dated 20th May, 1922.]

An Appreciation by Professor Wallace.

Professor Wallace, Edinburgh University, writing in *The Scotsman*, states :—

Mr. Garton was the originator of the successful method of multiple crossing in plant-breeding. With the assistance of his brother, Mr. Robert Garton, he began his world-renowned work on their farm at Newton-le-Willows about 1880, on a well-fenced two-acre lot, which rapidly grew to large dimensions. Towards the close of last century the late U.S.A. Assistant Secretary in Agriculture, Wm. M. Hays, a plant-breeder himself, who paid an official visit of inspection to all the agricultural plant-breeding stations in Europe and America, pronounced the work of John Garton to be far ahead of any he had seen. The success of his Garton method is most widely known to the whole English-speaking agricultural world through results got by crossing numerous species and varieties of oats, including wild oats, by means of which he introduced vigour of constitution and great yielding capacity to the new breeds, materially improving the food producing capacity of the best sorts of arable soils. John Garton's work extended to wheat, barley, roots and potatoes. It was on the last he first tried his 'prentice hand. Professor A. N. M'Alpine, Botanist to the Highland Society, dealt fully with his work on cereal plants in the "Transactions" of the Society in 1894, and with that on forage plants, clovers and grasses in his reports published in 1898.

Financial prosperity rapidly followed scientific achievement, and so early as 1900 (acting in conjunction with other members of the Garton family) this brilliant investigator established, and, later, permanently endowed the course of lectures on Colonial and Indian agriculture, which bears his name. This munificent gift

was made as a thank-offering for the recognition and sympathy extended to his early efforts by the Botanical and Agricultural Departments of Edinburgh University at a time when the cold, practical (not to mention the scientific) world preferred to turn its back upon them. Garton was an indomitable, untiring worker with unbounded enthusiasm in his work. Much of his plant-breeding was done in the early hours of the summer mornings when the rest of the world was asleep. He was an inventive genius of no ordinary kind, with a love for exploring the mysteries of nature and a determination to find the scientific explanation of the common incidents of life which the vast majority of people failed to comprehend or even notice. The main results of his observations are all carefully recorded in a characteristic legible hand, but, to the regret of his friends, his premature breakdown prevented him extending them into capacious volumes. He was an excellent public lecturer, a lucid and interesting speaker and expositor, and a debater who was difficult to tackle. He was widely read, especially in scientific literature, and was endowed with an exact and unfailing memory. His private circle of friends was not large, but the wide public circle who knew him only through the results of his scientific work cannot fail to realize that a remarkable man has been lost to the agricultural world at a time when it needed him most.

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COMMERCIALLY SUCCESSFUL WIND ELECTRIC PLANT.

SCIENTISTS, engineers and electrical men generally have dreamed for the past twenty-five years of utilizing the force of the wind to generate electric power which could be accumulated in a storage battery and used for lighting and power purposes as required on large estates and in the country houses. Many have not been content with dreaming of the day when this would be practical, but have constructed plants of their own and put them into service. Many of these home made plants have been in service for years. One of the most ambitious of these installations was described and illustrated in the September (1921) issue

of *Farm Light and Power.* This was capable of developing 7 to 10 horse power and has been in successful use for the last twelve years. The wheel and tower of that particular installation had been specially made for the purpose, but ordinarily, everyone who has experimented in this field has had to take what he could get in the way of a windmill and make his own transmission devices. Twenty-five years ago, the storage battery was also far from being what it is to-day, so that it is not to be wondered at that most of the experimental plants were very inefficient.

The Perkins Corporation, having built high grade windmills for the past sixty years, devoted a great deal of time and study to the solution of this problem, and has found it in the specially designed windmill, mounted on Hyatt roller bearings and using a gear box machined to automobile standards of precision to drive a specially designed Westinghouse generator, mounted directly on the turn-table that carries the wheel.

One of the first of these plants to be installed was set up on the property of Jacob Clauss at Milford, early in 1921. The editor of *Farm Light and Power* having been very much interested in the subject for twenty years past, went to see this installation at Milford within the past month or two, and it is quite evident from the successful service that it is rendering that thousands of these plants will be placed in use, not only in this country, but all over the world in the next few years.

With its precision mounting on roller bearings, the 14-foot Perkins wheel turns over in the merest breath of wind that cannot be felt on the ground. Small wheels and towers were the cause of many unsuccessful installations for pumping. The Perkins Corporation supplies a 50-foot tower, and sees that it is erected in a place where it will be entirely free from obstructions. As the generator begins to send power into the battery with the minimum wind of six miles per hour, it is important that it be placed on a tower which raises it above all surrounding buildings and trees. A 240-ampere-hour battery is supplied, and this is sufficient to cover the needs of an average house for lighting, pumping, running washing machine, milking machine, iron, vacuum cleaner and

similar appliances for a period of eleven days without any charge being put into the battery.

The Clauss installation is between the house and the barn, the battery being placed in the cellar of the dwelling. The house is completely wired from cellar to attic, and this is also true of the barn and the outhouses, while a 100 watt lamp is placed on the windmill tower to light the yard. During the several months that this plant has been in service, and this includes the midsummer months when the wind is lightest, there has never been a time when the generator could not produce more current than the storage battery could take care of, so that the wheel had to be kept reefed out of the wind 50 to 60 per cent. of the time. [*Farm Light and Power*, December 1921.]

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BRITISH COTTON GROWING ASSOCIATION.

THE 216th meeting of the Council of the British Cotton Growing Association was held in Manchester on 2nd May, 1922. The President (the Right Hon. the Earl of Derby, K.G.) occupied the chair, and there were also present Lord Stanley, Messrs. Astley-Bell, B. Crapper, J. M. Thomas, and a good attendance of members of the Council.

WEST AFRICA.

In the southern provinces of Nigeria the crop has suffered severely from unfavourable climatic conditions. There has also been a large demand for the cotton for the native spinning industry, and it is therefore anticipated that the Association's purchases will show a considerable reduction from last year's.

The cultivation of improved long staple cotton in the northern provinces continues to make steady progress, and the purchases of this type of cotton so far this year constitute a record, *viz.*, 7,357 bales, as compared with 5,016 bales for the same period of last year. The Association have concentrated their efforts for some years towards encouraging the cultivation of improved cotton in the northern provinces, and the results achieved have been most gratifying.

A commencement has been made with seed distribution, on the Bauchi line, in which district the demand is greater than previously. This, together with increased requisitions from the Katsina Emirate, augurs well for the 1922-23 season, and proves that the natives are willing to cultivate the improved cotton at the price of 2*d.* per lb. of seed cotton which the Association are paying for this year's crop.

Uganda.

The exports of cotton from Uganda in 1921 amounted to 81,340 bales, which constitute a record, and compare with 52,000 bales for the previous year. Unfortunately there has been a severe drought in most districts during the growing season of the 1921-22 crop, with the result that the production is expected to show a large falling off. At the same time efforts are being made to induce the natives to cultivate a second crop by early planting, in order to obtain a harvest about October-November. This has been done before and has been fairly successful. [*Textile Mercury*, 13th May, 1922.]

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BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION.

The first three numbers of Volume I (1922) of the "Shirley Institute Memoirs" have just appeared and, through the courtesy of the Director, Dr. A. W. Crossley, copies have been received in the library of the Indian Central Cotton Committee. The first number after referring very briefly to the formation of the British Cotton Industry Research Association and its objects and constitution and to the reasons which led to the selection of the "Towers" estate (of some 14½ acres) at Didsbury for this Association's Central Research Institute describes the organization and equipment of the latter. The Shirley Institute was aptly described by Mr. Kenneth Lee (Chairman of the British Cotton Industry Research Association), in his speech at the formal opening of the Laboratory by His Royal Highness the Duke of York, as the "General Scientific Head Quarters for the Cotton Industry."

Numbers II and III are papers by Dr. Oxley on "The Regularity of Single Yarns and its Relation to Tensile Strength and Twist", and Mr. Denham on "The Structure of the Cotton Hair and its Botanical Aspects", abstracts of which appear elsewhere in the *Agricultural Journal of India*. [B. C. BURT.]

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REGINNED AND CLEANED COTTONS.

IN a cotton-growing season of unusually heavy rainfall and early frosts, a considerable amount of low-grade cotton is thrown upon the market. A number of firms have undertaken to regin this low-grade cotton and others to clean it and thus improve the grade before the cotton reaches the mill.

Manufacturing tests of $\frac{7}{8}$ in. cotton of the above character have been made by the Federal Bureau of Markets and Crop Estimates to determine, if possible, its value. These tests were conducted in the Textile Department of Agricultural Engineering, Raleigh, N.C.

The cotton used in each case consisted of three lots: one lot represented a mixture of cotton before being reginned or cleaned; another lot represented the cotton after reginning or cleaning; and the third lot represented a different bale which equalled in grade the reginned or cleaned cotton. The cotton was classed by the Board of Examiners of the United States Department of Agriculture at New Orleans.

TEST No. 1 ON CLEANED COTTON.

In the process through which the cleaned cotton used for test No. 1 had passed there was a continuous passage through several machines commonly used in a cotton mill, such as bale breaker, a hopper feeder and Creighton opener. The cotton was then put up in flat bale form through the use of an ordinary press found commonly in gin houses. The original cotton, before cleaning, graded below Good Ordinary and the cleaned cotton and matched bale graded Strict Low Middling.

The test showed that the visible waste in the original cotton was 13·58 per cent., in the clean 7·73 per cent., and in the matched or bale of equal grade which had not passed through any cleaning process was 6·90 per cent. The cleaned cotton produced on an average a 5 per cent. weaker yarn than the original, but 17·1 per cent. stronger than the matched bale. This weakness of the matched bale is probably accounted for by the character of the cotton in the bale selected.

Test No. 2 on reginned cotton.

The machinery used in the process through which the reginned cotton used for test No. 2 had passed closely resembled the usual battery of gins. In each machine, however, the grids or ribs and breasts were removed, the cotton being fed to the saws through feed rolls that were adjustable for various lengths of staple. The lint was removed from the saws by an air blast instead of by a rapidly revolving brush. The reginned product was also put up in the regulation flat bale form through the use of an ordinary "square" press. The original cotton before cleaning consisted of a mixture of three bales, two of which graded Strict Good Ordinary and one Good Ordinary, while the reginned cotton and matched bale both graded Strict Low Middling.

The test showed that the reginned cotton gave off 3 per cent. less visible waste than the original cotton, and 1 per cent. less than the matched. The total visible waste on the original was 6·98 per cent., and on the matched 7·94 per cent. The reginned cotton produced on an average 5·88 per cent. stronger yarn than the original, but 14·48 per cent. weaker than that produced from the matched or equal grade. The character of the cotton in the matched bale perhaps had some effect on the greater breaking strength shown by the yarn produced from the matched bale.

Test No. 3 on reginned cotton.

The process through which the reginned cotton used for test No. 3 had passed was similar to that described in test No. 2, but differs from it chiefly in that the cotton was removed from the saws through the use of a brush instead of by a blast of air. The

original cotton before being reginned consisted of a mixture of three bales, two of which graded Strict Low Middling and one graded Middling, while the reginned cotton and matched bale both graded Strict Middling.

The test showed that the total visible waste on the original cotton was 6·63 per cent., on the reginned 5·18 per cent., and on the matched or bale of equal grade 8·34 per cent. The reginned cotton produced yarns 1·52 per cent. weaker than the original and 0·21 per cent. weaker than the matched bale. No suggestion is offered to explain why the matched bale showed a greater percentage of visible waste than the original cotton which was of lower grade.

TABLE I.

Total visible waste percentage and breaking strength in pounds per skein.

	Original cotton	Cleaned or reginned cotton	Matched bales
TEST No. 1 (*Cleaned cotton*).			
Percentages of visible waste	13·58	7·73	6·90
STRENGTH OF YARN IN PUONDS PER SKEIN OF 120 YARDS.			
8s.	223·4	211·7	193·2
12s.	143·4	137·5	118·9
16s.	104·0	100·3	85·8
22s.	71·8	68·5	56·4
28s.	44·1	40·8	33·4
TEST No. 2 (*Reginned cotton*).			
Percentages of visible waste	9·98	6·98	7·94
STRENGTH OF YARN IN POUNDS PER SKEIN OF 120 YARDS.			
8s	198·7	204·9	234·4
12s.	124·6	130·8	152·2
16s.	92·7	98·0	115·2
22s.	60·8	66·7	79·5
28s.	41·1	42·1	51·4
TEST No. 3 (*Reginned cotton*).			
Percentages of visible waste	6·63	5·18	8·34
STRENGTH OF YARN IN POUNDS PER SKEIN OF 120 YARDS.			
8s.	237·0	236·9	238·7
12s.	153·9	150·0	151·0
16s.	112·2	110·4	110·9
22s.	77·6	75·8	75·7
28s.	45·8	45·3	45·0

Table I gives the total visible waste percentages and the breaking strength in pounds per skein for the three tests. The visible waste and yarn strength results show that no definite conclusions can be drawn from these tests, hence these results should not be regarded as final. [*Textile Recorder*, XL, 470, 15th May, 1922.]

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COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

DISINFECTION OF COTTON SEED.

Two lots of seeds were subjected to rising temperatures of 60°C., 65°C., 70°C., and 75°C., for one, two and three hours. It was shown that up to 70°C., the vitality of the seeds treated for a time varying from 1 to 3 hours was not impaired ; at 75°C. the seeds nearly all died after 2 hours' treatment or else produced yellow, sickly seedlings. A temperature of 60°C. is enough to destroy all the animal parasites of the cotton plant. The seeds should be mixed with very fine dry sand, or saw-dust, previously heated to 60°C., and the mass maintained at that temperature for at least one or two hours. [*Bull. Agri. Intelligence*, 1921, **12**, 139–140 ; from *L'Agronomie Coloniale*, 1920, **5**, 103–104. E. SCHRIBAUX.]

STRUCTURE OF COTTON HAIR.

The authors summarize the results of observations on the structure of the cotton hair, made subsequently to the recognition of growth rings in the cell-wall. The following conclusions are drawn :—(1) A spiral fibrillar radial structure exists in every growth-ring of the cell-wall of the cotton hair, (2) the simple pits of the cell-wall are a special case of this general structure, (3) the pattern of the spiral appears to be pre-determined during growth in length, (4) this pattern is preserved through all the growth-rings of the secondary wall thickening, (5) the number of fibrils in cross section

of one hair is of the order of 1,000 upwards, (6) the pattern (direction, reversal and pitch) of these spirals seems to be the major determinant of the externally visible convolutions of the hair, (7) there are indications that the unknown cellulose-aggregates, which compose any one spiral fibril, have a definite geometric conformation, suggestive of stereo-isomerism, (8) attempts to elucidate cellulose structure further, as by X-rays, will probably have to take into account this spiral fibril arrangement. [*Proc. Roy. Soc.*, 1922, **B 93,** 426–440. W. L. Balls and H. A. Hancock.]

Cotton cultivation in French colonies.

A report of the committee of the Paris section of the Société Industrielle de Mulhouse, appointed to consider the question of cotton cultivation in the French colonies and the advisability of establishing an institute of colonial agriculture, states that cotton could be successfully produced in many of the colonies, but especially in West Africa and Cambodia and the colonies in Senegal and the Sudan, but scientific control is indispensable. A brief survey of the different organizations existing in France shows that none of these is suitable for the proposed scheme. Suggestions are therefore put forward for the immediate formation of a special organization which shall serve as a scientific and administrative headquarters for the control of cotton growing in the colonies. Reference is made to the work of the Empire Cotton Growing Committee in England and to the work of certain agricultural colleges in Belgium and Holland. [*Bull. Soc. Ind. Mulhouse,* 1922, **88**, 84–100. F. Koechlin.]

Preparation of staple diagram.

A simple process is described for preparing staple diagrams by counting the number and measuring the lengths of individual fibres. A carefully pulled tuft of fibres is laid on a board covered with velvet and gently pressed down with a microscope slide, care being taken not to disturb the arrangement of the fibres. The slide is moved so far to the right that the longest fibres protrude about 1 mm., then, by means of a pair of fine tweezers, one or more

of the fibres can be removed from under the slide and covered with another slide carrying a millimetre scale. In this way the whole tuft may be analysed. By this process it is said to be possible to separate and measure over 1,000 hairs in 4 or 5 hours. [*Deut. Faserstoffe u. Spinnpflanzen*, 1922, **4**, 43 ; from *Textile Forschung*, 1921, No. 4, 197–198. K. Berndt.]

We are indebted to the Secretary, Indian Central Cotton Committee, for the following abstract :—

The structure of the cotton hair and its botanical aspects, by H. J. Denham, M.A., British Cotton Industry Research Association. (*Jour. Text. Inst.*, XIII, 4, 1922.)

A résumé of existing information on the structure of the cotton hair and of such parallel instances in general botanical literature as can be used to throw light upon it. The paper is a valuable summary of the present position of our knowledge and shows clearly the great field for further work. The paper includes a bibliography of literature on the microscopy of cotton from 1834 onwards.

LATE ROBERT CECIL THOMAS PETTY, B.A.,

[Assistant Agricultural Bacteriologist, Agricultural Research Institute, Pusa.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

His Excellency Sir Henry Wheeler, K.C.S.I., K.C.I.E., I.C.S., Governor of Bihar and Orissa, paid a visit to Pusa on the 26th July, 1922, and inspected the work of the various Sections of the Institute.

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We offer hearty felicitations to Mr. James Mollison, C.S.I., M.R.A.C., First Inspector General of Agriculture in India, on the conferment of the degree of LL.D. by the Edinburgh University.

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Mr. J. F. Dastur, M.Sc., D.I.C., Supernumerary Mycologist, Agricultural Research Institute, Pusa, has been confirmed in the Indian Agricultural Service from the 30th June, 1922.

***

Mr. P. V. Isaac, B.A., M.Sc., D.I.C., F.E.S., has been appointed by the Secretary of State to the Indian Agricultural Service and posted at the Agricultural Research Institute, Pusa, as Second Entomologist (Dipterist).

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Mr. W. A. Pool, M.R.C.V.S., has been appointed Veterinary Officer, Imperial Bacteriological Laboratory, Muktesar, from the 6th March, 1922.

***

Mr. H. C. Sampson, C.I.E., B.Sc., Acting Director of Agriculture, Madras, has been granted combined leave for one year, four months and 13 days from or after the 1st August, 1922.

Mr. R. D. Anstead, M.A., Deputy Director of Agriculture, Planting Districts, Madras, has been appointed to act as Director of Agriculture as a temporary measure, *vice* Mr. Sampson on leave or until further orders.

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Mr. D. G. Munro, B.Sc., Superintendent, Central Farm, Coimbatore, has been appointed to act as Deputy Director of Agriculture, Planting Districts, *vice* Mr. Anstead. He will hold additional charge of the office of Superintendent of the Central Farm, Coimbatore, until relieved.

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Mr. E. Ballard, B.A., F.E.S., Government Entomologist, Madras, has been granted combined leave for one year from or after the 15th July, 1922, Rao Sahib Y. Ramachandra Rao, M.A., F.E.S., officiating.

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Mr. F. T. T. Newland, Government Agricultural Engineer, Madras, has been granted leave on average pay for three months from the date of relief.

***

Mr. J. G. Cattell, M.R.C.V.S., Professor of Pathology and Bacteriology at the Madras Veterinary College, has been permitted to retire from the Indian Civil Veterinary Department. Mr. Cattell has been granted, preparatory to retirement, combined leave for 13 months from the 5th June, 1922.

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Mr. E. S. Farbrother, M.R.C.V.S., has been appointed Officiating Superintendent, Civil Veterinary Department, Bombay, *vice* Mr. G. Taylor, M.R.C.V.S., on leave.

***

Mr. M. M. Mackenzie, Superintendent of the Sipaya Farm, Bihar and Orissa, has been granted leave on average pay for five months and one day with effect from the 30th June, 1922.

Mr. D. Quinlan, M.R.C.V.S., Director, Civil Veterinary Department, and Veterinary Adviser to the Local Government, Bihar and Orissa, has been granted further extension of furlough on medical certificate for three months.

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Lala Har Narayan Batham, M.A., Officiating Agricultural Chemist to Government, United Provinces, on being relieved, has been appointed to officiate as Assistant Agricultural Chemist to Government.

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Captain S. G. M. Hickey has been appointed to officiate as Veterinary Adviser to Government, United Provinces, *vice* Major E. W. Oliver granted combined leave up to 31st March, 1924.

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Captain W. H. Priston has been appointed to officiate as Second Superintendent, Civil Veterinary Department, United Provinces, *vice* Captain Hickey.

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Khan Sahib Munshi Niaz Muhammad has been appointed to officiate as Third Superintendent, Civil Veterinary Department, United Provinces, *vice* Captain Priston.

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Mr. P. S. Woolf, Cattle Breeding Expert to the Punjab Government, relinquished charge of his duties on the 6th June, 1922, on acceptance of his resignation.

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Mr. H. F. Robertson, Deputy Director of Agriculture, Burma, has been transferred from Insein and posted to the Irrawady Circle with headquarters at Myaungmya from the 1st July, 1922.

***

Mr. A. McLean, Deputy Director of Agriculture, Burma, has been posted to the East Central Circle with temporary headquarters at Mandalay from the 1st July, 1922.

Mr. S. T. D. Wallace, V.C., B.Sc., Officiating Deputy Director of Agriculture, Southern Circle, Central Provinces, has been appointed Deputy Director of Agriculture in charge of Animal Husbandry, Nagpur, from the 9th May, 1922, in addition to his own duties.

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Mr. J. C. McDougall, M.A., B.Sc., Assistant Director of Agriculture, has been appointed Officiating Deputy Director of Agriculture, Eastern Circle, Central Provinces, from the 9th May, 1922.

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Mr. E. A. H. Churchill, B.Sc., Assistant Director of Agriculture, Southern Circle, Nagpur, has been granted combined leave for six months from the 29th June, 1922.

***

Mr. J. Hezlett, I.C.S., has been appointed Director of Land Records and Agriculture, Assam, *vice* Mr. J. McSwiney, I.C.S., granted combined leave for two years and four months from or after the 11th July, 1922.

***

The notification appointing Mr. L. Barthakur provisionally Deputy Director of Agriculture, Assam, ceased to have effect from the 30th June, 1922. From the same date Mr. Barthakur has been appointed to officiate as Deputy Director of Agriculture, Assam Valley, during the absence of Mr. A. G. Birt on leave.

***

Mr. W. Harris, M.R.C.V.S., Superintendent, Civil Veterinary Department, Assam, has been deputed to undergo a course of post-graduate training at the Imperial Bacteriological Laboratory, Muktesar, for three months from the 1st July, 1922, Babu Guru Prasanna Sen officiating.

Mr. A. A. Meggitt, M.Sc., Agricultural Chemist, Assam, has been allowed combined leave for 2 years, 2 months and 28 days from or after the 3rd September, 1922.

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Dr. N. Kunjan Pillai, M.A., B.Sc., Director of Agriculture, Travancore, will preside over the Agricultural Section of the Indian Science Congress to be held at Lucknow in January 1923.

Reviews

A Manual of Elementary Botany for India.—By RAI BAHADUR K. RANGACHARI, M.A., L.T. Second Edition (revised and enlarged). Madras Government Press. Price Rs. 4.

A REFRESHING feature of this book is the illustrations. They are not copies from other peoples' books as so many botany book illustrations often are. In most cases they are clear and well chosen to illustrate the intended points from the Indian flora. There are a few, however, such as Figures 191, 192, 193, which are an exception. Figure 49 is a photo-micrograph of a longitudinal section of a root tip and not of a root tip as labelled. Of two photo-micrographs on page 261 one shows the features as well as the other does badly.

In some places we have found the language difficult to follow. We cannot quite accept the definition of cells as the "elementary organs" of plants. The modification of Pfeffer's classic experiment on page 170 deserves better treatment than to be put in such a way as to suggest that a "burst" membraneous bubble can reform itself. In the account on page 216 of the association between leguminous plants and bacteria a good opportunity is lost for an explanation of symbiosis, a term much more to be preferred than "mutual parasitism." The use of the term diœcious as suggested on page 243 with reference to the flower is not the usually accepted one in botanical nomenclature.

After a student has made a study of the morphology of typical flowers as he would have done in his preliminary studies it is well to introduce him to the study of systematic botany on evolutionary lines and proceed from the archaic to the more modern developments of floral evolution. The increased use of Engler's system in

taxonomy wants to be much more generally encouraged in Indian Botany. It is a typical unfolding of natural history, or the progress of nature as illustrated by plant development. We prefer to take groups like the Amarantaceæ and Urticaceæ at the beginning instead of the end of our systematic study. The study of classification on these lines is one of the best introductions to the œcological aspect which follows next when a student has learnt to recognize representations of plant population. By this method he learns firstly the relationships of plants within their own family as it were, and then sees their individual and communal struggles.

The Order Leguminosæ furnishes a common instance of history studied retrospectively. In English text-books of elementary botany the sub-order Papilionaceæ, if not the only one, is, generally, the first one to be described, because it is the only indigenous representative of that Order. In a text-book of botany for India it should be the climax of the description, the Mimoseæ and Cæsalpineæ coming first, for that is the order in which evolution has worked its way.

This book is eminently suitable for the use of teachers in our Indian schools and colleges as it furnishes them with a wealth of material drawn from Indian plants with which to illustrate their teaching. To such we can recommend it. [W. Y.]

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A VERY valuable **Text Book of Punjab Agriculture** has been issued under the names of Messrs. Roberts and Faulkner by the Civil and Military Press, Lahore. The authors have had ample opportunities of obtaining a first-hand knowledge of agricultural conditions in the Punjab which added to special scientific training renders them specially qualified to speak with authority on the subject.

The area of the Punjab proper is comparable in size with the total area of Great Britain. As 40 per cent. of the total wheat crop of India is produced in this province, any advances in the science and practice of agriculture are of prime importance. Some idea of the great strides made by the Punjab Agricultural

Department in its short life of some eighteen years can be formed from reading this book. Changed are the days and changed is the attitude of the general public from the time when the young department began its early struggles.

The chapter on Irrigation is a specially valuable one, and it is made fully evident how much the development of the country depends on the full utilization of the irrigation resources of the province. Eight million acres are already commanded by Government canals, and 45 per cent. of the total cropped area is under irrigation.

The work on the whole is clear and concise and the facts and figures have been very carefully compiled. The authors have, however, made a slip on page 78 in their reference to the Sind Fallow Rules. Instead of these, a local rule on the Jamrao canal has been quoted.

It is most desirable that similar text-books should be written for the other provinces of India uniform with this work. In addition to the data available to the Agricultural Department, much valuable information lies hidden away in Revenue Settlement Reports. This is seldom brought to light.

The paper, illustrations and binding of the book leave a good deal to be desired, and it is hoped that in subsequent editions these will be improved. [G. S. H.]

Correspondence

THE COPPERSMITH.

To

The Editor,

The Agricultural Journal of India.

Sir,

Mr. Bainbrigge Fletcher in his contribution on the Coppersmith says at p. 223 of the May (1922) Number of the *Agricultural Journal of India* :—"Like other Barbets, the Coppersmith is a frugivorous bird and seems to confine itself entirely to wild fig-fruits, not being known to attack cultivated fruits *at all.*" The last clause, however, is contradicted in a footnote on the same page which records the observation of Mr. Inglis who has seen this bird feeding on guavas. This trait seems to have been regarded by Mr. Fletcher as an exception and not a rule, as he has not attempted to explain the evidence of Mr. Inglis ; but, on the other hand, in the same paragraph, after citing seventeen cases of stomach-examination by Messrs. Mason and D'Abreu, he comes to this definite conclusion :—" From an agricultural point of view, therefore, this bird is of neutral value." This is the opinion also of Messrs. Mason and Lefroy (*Mem. Dept. Agri. India, Ent. Ser.*, III, p. 361).

My own experience, however, corroborates Mr. Inglis, and leads me to the view that this bird is as injurious to cultivated fruits as to wild ones. My countryhouse, which is about nine miles from Calcutta, shelters many Crimson-breasted Barbets which play havoc among my guavas, mangoes and mulberries. I have seen with my own eyes these birds destroying my fruits year after

year. The stomach-examination of only seventeen of these birds does not give us the data from which we can come to some conclusion as to their economic value. In seasons when there are no crops of cultivated fruits, they have naturally to live on *Ficus* fruits and wild berries. It is also probable that the birds took earlier in the day cultivated fruits which were digested and assimilated, after which they ate *Ficus* fruits when they were shot for stomach-examination. Mr. Blanford's observation is that they are " found in almost every garden, mango-grove and banian tree " (*Fauna*, Vol. III, p. 99). Why should they live in gardens and mango-groves if they do not live on their produce ? The natural conclusion would be that they take both *Ficus* and cultivated fruits, whichever are easily available.

In the last paragraph of the same article (p. 224), the writer says :—" The Coppersmith seems rather an ill-natured little bird and is therefore not adapted to be a desirable inmate of a mixed aviary." This again is not true so far as my experience goes. I have regularly kept this bird in my aviary which contains no less than twenty varieties of birds and I have never found them quarrelling with any. One bird has been with me for the last six years and is still in perfect health. Small birds like White-eyes have been all along its companions, and I have never seen any attempt on its part to molest them. It is aggressive only towards its kindred, so that more than one pair of these birds cannot be housed together. Otherwise it is quite amiable, and excellent as an aviary bird. The Blue-throated Barbet (*Cyanops asiatica*) or the *burra bussunt* is of course an ill-tempered, quarrelsome bird and cannot be entertained in a mixed aviary, but not the beautiful little *Xantholæma hæmatocephala* which does not certainly deserve such adverse reflections on its character.

In my aviary I have kept these birds on a mixed diet of *satoo* paste, *satoo* fried in *ghee*, insects, bread-and-milk sop, and of course fruits which they prefer most. Such mixed diet, instead of proving " poisonous," really does good to their health. When I empty a tin of grasshoppers before them, they, and specially the Blue-throated ones, attack them as greedily as the purely insectivorous

birds. I may add here that, given both cultivated and wild fruits, they show a decided preference, like the Bulbuls, for the former.

At page 221, in the second paragraph of the article, Mr. Fletcher writes :—" The Crimson-breasted Barbet.........belongs to the family of Barbets which comprises upwards of twenty species of *smallish*.........birds." That adjective " smallish " is rather unhappy. The Crimson-breasted Barbet is the smallest in the whole family of Barbets except one (*Cyanops cyanotis*) which is, however, of the same size. The rest are all bigger, and there are some which are as big as a foot or nearly a foot in length. By a reference to the *Fauna of British India*, Vol. III, it will be found that they are all more than seven inches in length. The average Barbet is of the size of an Oriole which is not a small bird and therefore the family of Barbets cannot, by any stretch of imagination, be called " smallish " which, I understand, means " rather small."

In passing, I mention an interesting field-habit of this bird. During the nesting season it seems to develop an instinct for territorial possession. Any encroachment on its territory by a bird of the same species is strongly resented and actively opposed. At such times, duels between the Crimson-breasted Barbets become common. In a tree near the Fort William in Calcutta, I once noticed such a fight. A pair of these Barbets had selected a hole in the tree for their nursery. Another male evidently intruded upon them and was at once attacked by the male-bird of the pair, the female looking on. The fight was grim and long and was fought with evident determination on both sides though ultimately the intruder had to retire defeated from the field. So engrossed were they with their combat that they forgot my presence and fell struggling with a thud at my very feet where they separated and flew up only to come to grips again. This happened not once but as many as four times.

CALCUTTA,
4th July, 1922.

Yours faithfully,
SATYA CHURN LAW.

WITH reference to the foregoing observations, the economic status of the Coppersmith, as of other animals, is probably subject

to local conditions. In writing an article of this nature for the *Agricultural Journal of India*, consideration has to be paid to the conditions throughout the whole range of distribution of the particular bird, which often occurs all over the Indian Empire, and it is therefore necessary to give a general account as far as possible. That the Coppersmith may at times damage cultivated fruit is more than probable ; that it is, generally speaking, a regular pest of fruit I do not believe. We have certainly never received any complaints of it in this respect, nor do I find any statements to this effect in literature on Indian birds. Cunningham, who was a keen observer of birds in and around Calcutta, writes :—" Whilst at large, they feed on fruits and buds of many different kinds, the ripening receptacles of many figs, and especially those of *Ficus nitida* and *F. rumphii*, being particular favourites." At Pusa we have many wild figs of several species, and there always seem to be ripe fruits throughout the year, so that the various birds which normally live on these fig fruits have perhaps less occasion to attack cultivated fruits than in other districts where their normal food may fail at times.

I quite agree that examination of only seventeen bird-stomachs cannot give us more than a slight indication of the nature of the normal food-supply. But that is all the information available so far, supplemented of course by observations of the birds under natural conditions.

Our correspondent's account of his Happy Family of twenty kinds of birds is interesting. Of the habits and temperament of birds in captivity, however, I cannot speak at first-hand. To vary slightly the words of the poet—

> " No bird that haunts my compound free
> To capture I condemn,"

and my observations on this point were freely adapted from Cunningham, who says (*Some Indian Friends, etc.*, p. 109) :—" Coppersmiths are ill-natured little birds, and are apt to commit unprovoked assaults on one another, or on any other small birds whom they may meet in the course of their wanderings. This in itself is enough to make them undesirable inmates of a mixed

aviary, but, in addition to this, there are difficulties in regard to their food when they are associated with other kinds of birds.'' Finn also (*Birds of Calcutta*, p. 73), says :—" The Coppersmith seems to make an intelligent and interesting pet if hand-reared, but he is not sociable with other birds, though not aggressive. But..........he requires a clear space round him, and if he be crowded either with his own species or with other birds, there will be trouble, for barbets are hard bitten birds and tenacious of what they conceive to be their rights ; indeed, a couple of wild Coppersmiths have been seen to fight till one was quite worn out.''

May I add that it is pleasing to find that this series of Bird articles evokes sufficient interest to elicit criticism and that such is always welcome. On conclusion of the series in the *Journal* these articles will probably be reprinted in book form and any further observations offered by our readers can then be inserted. It is extraordinary how little information there seems to be on record regarding the habits, food, etc., of many of our commonest Indian Birds, and what a wide field there is for those who are sufficiently interested to note down such facts under field conditions. [T. B. F.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Practical Plant Biology: A Course of Elementary Lectures on the General Morphology and Physiology of Plants, by Prof. H. H. Dixon. Pp. xi + 291. (London: Longmans, Green & Co.) Price 6*s.*
2. Basic Slags and Rock Phosphates, by Dr. G. S. Robertson. Pp. xvi + 120. (Cambridge: At the University Press). Price 14*s.* net.
3. Agricultural Research and the Farmer: A Record of Recent Achievement. Pp. 168. (London: H. M. Stationery Office). Price 2*s.* 6*d.* net.
4. Feeding of Dairy Cattle, by A. C. McCandlish. Pp. 281. (London: Chapman & Hall.) Price 12*s.* 6*d.*
5. Brazilian Cotton: Being the Report of the International Cotton Mission through the Cotton States of São Paulo, Minas Geraes, Bahia, Alagôas, Sergipe, Pernambuco, Parahyba, Rio Gramde do Norte, by A. S. Pearse. Pp. 231. (Manchester: International Federation of Master Cotton Spinners.) Price 21*s.*

The following publication has been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoir.

1. The Inheritance of Characters in Rice, II, by F. R. Parnell, M.A., Ag. Dip. (Cantab.), with the assistance of G. N. Rangaswami Ayyangar, B.A., K. Ramiah, L.Ag., and C. R. Srinivasa Ayyangar, L.Ag., (Botanical Series, Vol. XI, No. 8.) Price R. 1-4 or 1*s.* 8*d.*

Original Articles

SOME COMMON INDIAN BIRDS.

No. 18. THE INDIAN TREE-PIPIT (*ANTHUS HODGSONI*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, F.E.S., F.Z.S., M.B.O.U.

THE Pipits, contained in the genus *Anthus*, are all rather dull-coloured birds in shape like wagtails, to which indeed they are closely allied, and may be recognized by their streaked upper plumage and comparatively short tail. About a dozen different species occur within the Indian Empire and resemble one another very closely, so that they are difficult to distinguish in the living condition, their identification depending on such small points as the length of the hind claw. To the ordinary observer, then, all the Pipits look much alike and a bird which is seen to look much like the one depicted in our Plate may be set down as a Pipit but may not necessarily be the Indian Tree-Pipit. Pipits as a class are very highly parasitized by the Common Cuckoo, several species of these birds having been found to be victimized in this way, but apparently there is no record of the subject of our present article having been made use of as a foster parent.

It is seasonable to write of this bird at this time of the year as the Tree-Pipit is only a winter visitor to the Plains of the greater portion of the Empire, being found as far West as the Sutlej Valley in the Himalaya and Rajputana and Gujarat in the Plains, and as far South as the Palni Hills. In Bihar and Bengal it appears amongst the very earliest of the autumnal immigrants and remains in considerable numbers until about April, but during the summer it retreats to the upper ranges of the Himalayas and beyond to Siberia, North China and Japan. When they first arrive in India in the autumn their plumage is in fine condition and brightly marked but their colour becomes decidedly duller during their stay.

Tree-Pipits are very partial to mango groves and are rather shade-loving birds. However, they also frequent open spaces, such as garden paths, much in the same way as the Wagtails, and similarly keep their tails in constant rocking motion whilst pacing over the ground. When preparing to take flight they have a curious habit of swaying themselves about for a time, and when alarmed they fly up to the nearest tree and walk about on the branches in a decidedly un-wagtail manner. They are fairly social and frequently go about in small flocks, and feed on the ground on seeds of grass and weeds and on small insects. Seeds are oftener consumed by these birds than by the Wagtails, which are practically totally insectivorous. The late C. W. Mason examined the stomach-contents of sixty-seven birds at Pusa and Mr. D'Abreu those of three birds at Nagpur, and in all these seventy cases the birds contained seeds of weeds, injurious or neutral insects, and a few small snails. From an agricultural point of view, therefore, the Tree-Pipit may be put down as a decidedly beneficial bird, in spite of which fact it is commonly sold in the markets as an "Ortolan".

The Tree-Pipit does not breed in the Plains and indeed nests but sparingly within our limits and then only at an elevation of eleven or twelve thousand feet where it has been found nesting in Northern Kumaon. Here it affects by preference the more open grassy slopes in the immediate vicinity of woods; these open

glades are thinly covered with trees and overgrown with beautiful thick, soft, velvety grass, about a foot high, with occasional tussocks, under which are concealed the nests, built of dry grass-blades, or of green moss lined internally with fine grass-stems. The eggs, which are very large for the size of the bird, are shortly described as " very black-looking."

Mr. C. M. Inglis found the nests of this bird at Sandakphu (elevation 12,000 feet) in the Darjiling district on 2nd July 1904 and also at Tonglu (elevation 10,000 feet) on the following day. Sandakphu has a kind of alpine pasture, the ground being carpeted with many beautiful herbaceous plants of alpine character, such as Primulas of several kinds and aconite ; also amongst the rocks occurs a common stiff-branched shrub (*Potentilla fruticosa*, Linn.) with handsome yellow flowers and silvery foliage. The nests were found on the sloping grassy banks, generally hidden under a clump of grass, often also close to the rocks. On 2nd July young birds had already hatched out but fresh eggs were obtained on the following day.

During the 1921 Mount Everest Expedition a specimen of the Indian Tree-Pipit was collected on East Everest at a height of 17,500 feet and this species was observed migrating on the side of Mount Everest at an elevation of 20,000 feet.

The name *maculatus*, under which this bird is described in the " Fauna " volume, must be abandoned as preoccupied and its correct name is apparently *Anthus hodgsoni.*

THE RECLAMATION OF THE DESERT AREA OF THE KAPURTHALA STATE.

BY

D. R. SETHI, M.A., B.Sc.,

Deputy Director of Agriculture, Orissa Circle.

(*Formerly Director of Agriculture, Kapurthala State.*)

A VERY large part of the State of Kapurthala consists of the desert tract which extends into this region of the Punjab from Rajputana. This area is mainly composed of very light sandy soils in which numerous small sand dunes occur. Most of this portion of the State is cultivated under *barani* (unirrigated) conditions and the crops depend entirely on the rainfall. As a rule, the yields are very low due to the extremely porous nature of the soil and to the scantiness of the rainfall. A considerable area of this sandy tract is not cultivated at all and bears little beyond the wild grass known as *sarkanda* (*Saccharum spontaneum*). Here and there, however, well cultivated areas occur which depend for their water supply on wells worked by Persian wheels. These well irrigated tracts are very heavily manured with cowdung and village ashes and bear good crops. The existence of these small scattered areas suggested the possibility of the reclamation of the desert area on a large scale. As a result of the enquiries that were made, the Kapurthala Darbar decided to investigate the whole problem. An area of about 100 acres, the worst of its kind to be met with in this tract, was acquired in 1918 but the reclamation work did not start till the beginning of the following year. Plate XXXII, fig. 1 gives a good idea of the condition of this area at the time of acquisition and before the reclamation work was begun. The

Fig. 1. Typical desert area of Kapurthala State.

Fig. 2. Young crop of cluster-beans on reclaimed land.

purpose of this paper is to place on record the methods adopted and the progress made in this undertaking.

It seemed probable that the chief things needed for reclaiming this land and obtaining the full advantage of its natural porosity would be :—

(1) An ample supply of water free from alkali salts.
(2) The levelling and grading of the surface for irrigation.
(3) A supply of organic matter for binding the sand and supplying the necessary amount of humus and combined nitrogen.

Water supply.

If ordinary wells were employed, fifteen Persian wheels would be required to irrigate the whole area. This would involve not only a very large sum of money for the construction of the wells but also the purchase of the necessary bullocks. It was, therefore, decided to sink a large tube-well and to run this by power driven machinery. Boring was started in the middle of 1919. Samples of the various strata passed through were carefully bagged, and when the boring was completed at 200 feet from the surface these were sent to Mr. John Ashford, of the Punjab Irrigation Department, for analysis and report regarding the probable yield of water. The analyses showed that the well was likely to yield a little more than 30,000 gallons of water per hour. The surface spring level was found at 25 feet from the ground level, but really good water bearing sands were not reached until after 125 feet. As the estimated yield of water from the well was more than sufficient for all the requirements of the area under reclamation, further boring was not considered necessary.

The well was equipped with 104 feet of Ashford patent ten-inch strainer. The pumping plant consisted of an Ashford-Leggett patent vertical spindle turbine pump and a 25 B.H.P. crude oil engine. It may be mentioned that owing to the high lift a specially designed pump had to be installed. The well started working towards the end of 1920 and is yielding now a constant supply of 34,000 gallons per hour. Its chemical composition was determined

by the Chemist to the Sanitary Commissioner of the Punjab, which shows that the water is free from alkali salts and suitable for irrigation purposes.

TABLE I.

Composition of the water of the Kapurthala farm tube-well in parts per 100,000.

Albuminoid ammonia	0·012
Free ammonia	0·006
Oxidizable matter	nil
Permanent hardness	2·7
Temporary ,, ...	7·3
Total solids	24·0
Chlorides	1·065
Sulphates	traces
Iron, lime, sulphuretted hydrogen and nitrites	absent
Nitrates	traces
Free carbonic acid	nil

Having obtained an adequate supply of irrigation water, steps were taken to insure that large quantities were not lost through seepage in the earth channels leading from the well to the fields. This was accomplished by lining and puddling the floor of the channels with clay obtained from low-lying areas in the neighbourhood. With the flow of water a certain amount of sand is deposited over the clay linings. This is allowed to remain in position as it assists in limiting erosion. To prevent the falling in of the sides of the trenches a slope of not more than thirty degrees is arranged for at the time of digging.

LEVELLING AND GRADING.

From April to the middle of June very strong, dry easterly winds are the rule in this tract. In levelling the area, these strong winds were made use of by the following method. A little before the usual period of these winds, the uneven fields were ploughed and cross-ploughed so that the upper soil was in a thoroughly loose condition. As soon as the winds began the fields were kept constantly harrowed with a chain harrow which stirred up the loose soil which was carried away and deposited in the hollows. This procedure was kept up throughout the season and considerable expense in levelling was thereby saved.

Another method employed was the ordinary one of first breaking up the land and then levelling it with country made levellers. The only departure from the local custom was the use of tractors instead of bullocks for hauling the levellers. This helped to get the work done quickly. The speed of the machine had to be kept slow in order to enable the men handling the leveller to keep pace with it.

THE SUPPLY OF ORGANIC MATTER.

Before these lands could be called upon to grow a crop it was essential that they should be supplied with very large amounts of organic matter for binding the sands together, for increasing their water-holding capacity and for providing the raw material needed for the nitrification processes in the soil. The cheapest way of doing this appeared to be by means of green manure ; various leguminous plants, such as cow-peas, cluster-beans and sann-hemp were tried on a small scale. Of these sann-hemp proved to be the best. This crop gives a large quantity of green matter in a short time. It is capable of withstanding drought for a long period and the vegetable matter when ploughed into the land decays rapidly. For these reasons sann-hemp is now employed for green-manuring purposes at Kapurthala. It is usually sown in the third week of June soon after the first good monsoon shower. It is ready for ploughing in after about seven to eight weeks. A heavy wooden beam is run over the standing crop which enables it to be ploughed in easily. The green crop decays in about a fortnight.

The effect of green manure on the loose sands of this tract is extraordinary. Before the green crop, the soil particles are loose and do not hold together, but after the first green-manuring these begin to cohere and when the land is ploughed the furrow slice does not crumble.

THE ADDITION OF CLAY.

Another method of improving the cohesion of these loose sands and at the same time of increasing the supply of plant food is the introduction of clay. Carting the clay from the lowlands

and applying it directly to the fields was not successful as it was found difficult to mix it thoroughly with the soil. Moreover, the method proved expensive. A simpler and cheaper means had to be devised. This consisted in carting and stacking the clay, during slack periods, near the tube-well. Some of the clay is thrown into the main delivery tank of the well and whenever fields are irrigated a man keeps this earth stirred with his feet. The irrigation water carries the clay in suspension to the fields where it is evenly distributed. By cultivating the lands afterwards, the clay is thoroughly mixed with the sandy soil.

The reclaimed land.

That the good soil aeration of these poor and inhospitable sands makes them capable of yielding good crops after reclamation has been successfully demonstrated by the work of the past two and a half years. Good crops of maize, cotton, wheat, sugarcane, *shaftal* (*Trifolium resupinatum*), *senji* (*Melilotus parviflora*), cow-peas and cluster-beans are being grown on this land. Plate XXXII, figs. 2 and 3 give an idea of some of these crops, which are only possible if means are taken to keep up the supply of organic matter.

The important problem of working out the economics of a tube-well in these sandy tracts has not yet been completed. This is being done and it is hoped that definite results will be available within the next two or three years.

As our knowledge advances, tube-wells are bound to figure prominently in the reclamation of such sandy tracts where flow irrigation from canals is not possible on account of the permeable character of the soil. As these wells may fall off in yield in the course of time, due to the liability of the strainers to choke, a new type of strainer has recently been invented and patented by Mr. Stephen Leggett, M.I.C.E., of the Punjab Irrigation Department. By its means it is hoped that the tube-well problem, so far as it concerns the maintenance of yield for indefinite periods, will be solved.

THE RELATIVE NITRIFIABILITY OF DIFFERENT NITROGENOUS ORGANIC MANURES IN SOME TYPICAL SOILS OF THE CENTRAL PROVINCES AND BERAR.*

BY

F. J. PLYMEN,

AND

D. V. BAL,

Of the Department of Agriculture, Central Provinces and Berar.

EXPERIMENTS on the relative nitrifiability of nitrogenous organic manures in black cotton soil were formerly conducted and the results obtained embodied in a paper read before the Indian Science Congress in the year 1919[1]. This work has been continued and some phases of the decomposition of various organic manures in other typical soils of these provinces have been investigated. The results obtained are recorded in the present paper. The work upon black cotton soil has been extended to other organic substances and for the sake of comparison the results previously obtained are also included in this paper.

The organic manures employed in this experiment with their respective organic nitrogen percentages were as follows :—

Number	Name	Total nitrogen percentage
1	Karanja (*Pongamia glabra*) cake	4·38
2	Mahua (*Bassia latifolia*) cake	2·55
3	Castor (*Ricinus communis*) cake	3·90
4	Sarson (*Brassica campestris*, var. *napus*) cake	4·72
5	Tili (*Sesamum indicum*) cake	6·22
6	Undecorticated cotton seed (*Gossypium*, sp.) cake ..	5·33
7	Linseed (*Linum usitatissimum*) cake	4·74
8	Groundnut (*Arachis hypogœa*) cake	8·40
9	Mahua refuse (Flower of *Bassia latifolia*)	2·09
	Nitrogen as nitrate was found to be absent in all the samples.	

* Paper read at the Ninth Indian Science Congress, Madras 1922.

[1] *Agri. Jour. India*, 1919, p. 414.

Care was taken to use materials of approximately the same size by passing the finely ground samples of the various manures through a 1 mm. sieve. Instead of adding a definite and uniform quantity of nitrogen to the soil, a fixed quantity of manure, namely, one per cent. of the weight of the soil, was employed. The mechanical texture of the soil is thus modified to the same extent as far as possible.

Five different soils were employed in this experiment and a short description of each of these is given below :—

(*a*) *Bhata soil.* This is a lateritic soil of reddish colour containing a very high proportion of stones and gravel and only a low proportion of fine material. There are extensive areas of this soil in the districts of Raipur and Drug, most of which are lying waste at present. Minor millets may, however, be grown once in two or three years on such small areas as are brought under cultivation. The rainfall in the *bhata* soil tract is fairly heavy, amounting to an average of about 50 inches. In low lying areas much rice is grown but from the higher lying *bhata* soils the water readily runs off while the soil in itself admits of easy drainage. It is, therefore, essentially an open, well-aerated soil and without irrigation is only suitable for wet weather cropping.

(*b*) *Wardi soil.* This soil is very similar to *bhata* but is not so hard and stony. It is found in extensive areas in the Chanda District and is a light coloured soil of a sandy nature with just sufficient clay to keep it from crumbling in the dry season. Owing to irrigation facilities in this district, *wardi* is a very popular soil. It does not get waterlogged and with full irrigation and some manure it gives a good crop of rice and sugarcane. The soil used in this experiment was taken from the Government Farm, Sindewahi, from a field cropped with cane in rotation with open field crops like *juar* (*A. Sorghum*), cotton, etc. The area from which the sample was taken has only been reclaimed from jungle for a few years.

(*c*) *Domatta soil. Domatta*, as the name implies, consists of a mixture of soils and is found in the north of the Central Provinces. The soil is cropped with both wet and dry season crops, the choice depending upon the situation and texture of the soil. Amongst

the *kharif* (monsoon) crops those commonly grown are rice and sugarcane. Many vegetable crops are also grown on this class of soil in the garden areas near important towns. The soil used in this experiment was from a field where sugarcane and other similar crops are grown but not rice. It contains a relatively low proportion of fine material and is therefore a soil light in texture.

(*d*) *Black cotton soil.* This soil is the common type of ordinary black cotton soil as found over large areas in the Central Provinces and Berar and many parts of the Deccan. As it contains a high proportion of clay and fine silt the soil can be classed as distinctly heavy in texture. Climatically it suffers from a long dry period following the wet conditions of the monsoon. During the dry season the soil cracks and becomes thoroughly aerated in addition to whatever cultivation it may receive. As the rainfall in the black cotton soil tract is not particularly heavy, amounting on an average to from 34 to 46 inches, the soil is one upon which open cultivation is practised, the main crops being cotton, *juar*, pulses and occasionally wheat.

(*e*) *Sihar soil.* This soil is extensively found in the Balaghat District. It is a light yellow soil consisting chiefly of fine sand and when dry cracks little, if at all. This soil grows the finest varieties of rice but varies a good deal in quality according to its depth and crop-producing power. As is well known, the cultivation given to rice fields is of a semi-anaerobic nature. The fields are full of water during the rainy season and, further, the soil is puddled thoroughly at the time of transplanting the rice seedlings. It must be remembered, however, that between succeeding monsoons the soil is thoroughly dried and baked by the sun.

The five soils under investigation can be classified as follows :—

Soils (*a*), (*b*), (*d*) and, to a slightly less extent, (*c*) are all cultivated in the open season and thereby tend to become well-aerated. Soil (*e*) on the other hand remains for a certain time of the year under distinctly anaerobic conditions, this period being followed by one during which no cultivation is given.

It will be seen from the figures for organic nitrogen given in Table II that *bhata* and *wardi* soils are considerably higher in

nitrogen content than the others. This can probably be attributed to the fact that the *bhata* and *wardi* soils have been under fallow or scrub jungle for a large proportion of their existence whereas the other three soils have been continuously cropped.

The nature of the various soils mentioned above will be seen from the mechanical analyses given in Table I.

TABLE I.

Showing the mechanical analyses of the soils used. Percentage on fine soil passed through 1 *mm. sieve.*

	Name of soil				
	Bhata	Wardi	Domatta	Black cotton	Sihar
% stones and gravel on fine soil ..	223·00	91·00	14·20	11·10	13·00
Coarse sand	31·87	22·14	22·59	6·04	10·40
Fine sand	16·83	35·09	37·57	4·23	40·20
Silt	15·98	5·95	17·77	10·79	17·67
Fine silt	11·72	9·30	7·93	21·82	12·39
Clay	14·82	20·28	11·10	45·62	14·79
Moisture	2·19	2·48	1·71	6·37	0·94
Loss on ignition	6·57	4·62	1·42	5·68	3·06
$CaCO_3$	0·25	0·14	0·31	0·10	0·04
TOTAL ..	100·23	100·00	100·40	100·65	99·49

TABLE II.

Showing saturation capacities and nitrogen in the soils used.

Name of soil	Percentages on air-dry soil					
	Initial moisture	Saturation capacity	Initial NH_3	Nitrates	Nitrites	Nitrogen
Bhata	2·19	36·0	nil	nil	nil	0·077
Wardi	2·48	40·0	..	..	..	0·094
Domatta	1·71	36·3	..	traces	..	0·047
Black cotton ..	6·37	66·6	nil	traces	..	0·042
Sihar	0·94	36·1	..	nil	..	0·040

The saturation capacity was determined by Hilgard's method in a layer of 1 cm. depth.

The procedure followed was exactly the same as described in the previous paper except that the jars containing the soils were incubated at 30° to 33°C. instead of at room temperature. The soil after mixing with the appropriate kind and quantity of organic matter was moistened to optimum moisture content for nitrification as determined by previous experiment, *viz.*, to about 50 per cent. of saturation capacity. The whole was placed in wide mouth glass jars loosely covered and then kept in an incubator. At intervals of 15 days samples were removed for analysis after making good any loss of water. Nitrites and nitrates were estimated by the Griess Ilosvay and phenol-disulphonic acid methods respectively.

The percentages of oxidized nitrogen as determined by the above mentioned methods are given in Table III.

The results obtained can be examined for each soil individually.

Bhata soil. Castor cake appears to nitrify very well in this soil while *karanja, sarson* and cotton cakes come next. The nitrogen of linseed and *tili* cakes does not seem to be very susceptible to the action of nitrifying organisms. *Mahua* refuse is even less responsive and *mahua* cake was not nitrified at all during a period of 8 weeks. Groundnut cake appears to be relatively a slowly decomposing manure.

Wardi soil. The various forms of organic matter used seem to decompose in this soil in almost the same order as in *bhata* soil. One point is, however, noticeable, *viz.*, that the percentage of nitrogen nitrified in most of the manures in *wardi* soil is a little higher than that obtained in the *bhata* soil. The nitrogen in groundnut cake again does not seem to undergo a rapid oxidation.

Domatta soil. Here again castor cake seems to be the one most readily nitrified, while *sarson* and cotton cakes are nearly as good as castor. Linseed and *tili* cakes come next in order. With the exception of *mahua* cake, which was not nitrified at all during a period of 8 weeks, groundnut cake comes last.

TABLE III.

Showing the percentage of nitrogen nitrified in a period of 8 weeks in Black cotton, Bhata, Wardi, Sihar and Domatta soils.

	PERCENTAGE OF TOTAL NITROGEN NITRIFIED																			
Name of manure	BHATA SOIL				WARDI SOIL				DOMATTA SOIL				BLACK COTTON SOIL				SIHAR SOIL			
	Week				Week				Week				Week				Week			
	2nd	4th	6th	8th	2nd	4th	6th	8th	2nd	4th	6th	8th	2nd	4th	6th	8th	2nd	4th	6th	8th
Karanja cake ..	2·92	29·20	40·93	55·57	2·96	26·50	36·80	58·92	14·60	..	40·90	52·60	1·75	36·38	64·04	64·04	nil	3·68	14·72	26·52
Mahua cake ..	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	..	..	..	..
Castor cake ..	3·28	32·84	39·40	65·72	8·20	36·60	53·27	78·82	29·50	..	65·70	65·70	1·97	16·39	72·25	65·69	nil	9·88	29·98	33·30
Sarson cake ..	nil	32·56	43·41	51·56	4·80	27·16	46·11	54·31	19·00	..	54·20	59·70	1·63	20·42	54·51	54·51	nil	6·78	24·44	40·72
Tili cake ..	nil	28·82	37·05	45·30	5·50	40·99	45·34	59·44	14·42	..	45·30	49·40	2·84	16·53	57·83	66·11	0·512	10·24	36·90	45·09
Undecorticated cotton seed cake ..	2·40	24·03	38·44	48·06	4·80	43·33	52·98	60·16	18·00	..	48·00	60·00	2·90	38·39	60·41	67·66	0·395	6·02	24·06	31·30
Linseed cake ..	5·00	26·90	43·05	45·76	3·76	26·90	45·72	53·80	16·80	33·62	48·43	48·43	35·50	64·80	51·20	67·50	0·360	6·72	16·80	21·52
Groundnut cake	0·47	19·20	38·42	39·96	6·35	30·74	38·40	38·42	24·40	24·13	27·70	27·70	35·05	76·36	86·06	82·99	traces	13·96	12·30	12·30
Mahua refuse ..	16·42	19·70	22·13	22·13	12·30	14·74	16·00	18·43	12·30	12·30	17·23	17·23	4·30	14·65	14·65	20·70	12·290	12·29	24·50	24·58

Black cotton soil. Results with the first 6 manures in the list have already been described in the previous paper, and it is necessary here to consider only those results affecting the decomposition of linseed and groundnut cake and *mahua* refuse. With all the soils tested in this experiment this is the only one which was found to nitrify satisfactorily the highly nitrogenous groundnut cake and this was accomplished even to the extent of 86 per cent. of its nitrogen.

Mahua refuse is again shown to be only nitrified to a limited extent. In view of the prevailing opinion that black cotton soil is of a higher degree of fertility than many Indian soils it is interesting to observe that the nitrifying power of black cotton soil is generally better than that of the other soils examined.

Sihar soil. The nitrifying power of this soil is distinctly less than that of the other soils under experiment. This may be due to the different type of cultivation practised on *sihar* soil as described above. The maximum percentage of nitrogen nitrified is only 45 per cent. which figure was obtained in the case of *tili* cake. It appears that the semi-anaerobic cultivation given to such soils affects their nitrifying power. It will be noticed that as a rule under the conditions of the experiment very little nitrification takes place in the first two weeks but after the expiry of a further similar period a fair amount of nitrate was found. In this connection it must be remembered that the soils when taken from the field were in a dry state. From other observations, the authors have reason to think that this delay in the commencement of nitrification would not be experienced in the warm, moist conditions of the soil in the field.

The results obtained in these experiments may now be considered from another point of view. In the discussion above the various soils have been compared amongst themselves but the results can also be used to assist in determining the type of soil for which any given oilcake might be found suitable. Castor cake, for example, apparently suits all types of soil although in *sihar* soil *sarson* and *tili* cakes appear to be more completely nitrified. The nitrification of castor cake appears however to

proceed rapidly and this substance may therefore be considered as a quickly acting manure. *Karanja*, *tili*, *sarson*, undecorticated cotton and linseed cakes appear to be fairly similar in their response to nitrifying agencies but it must not be presumed that the authors recommend valuable foodstuffs such as linseed and groundnut cake to be used directly as manures.

The non-nitrifiability of *mahua* cake has already been commented upon by the authors in their former paper quoted above. Further experience with a variety of soils shows this material to be very resistant to nitrifying organisms and therefore of little manurial value.

It is perhaps necessary to point out the difference between *mahua* cake and *mahua* refuse. The former is the residue left after oil has been pressed out of the *mahua* seed (*Bassia latifolia*). *Mahua* refuse is a distillery waste, being the residue left after alcohol has been distilled from fermented *mahua* flowers. The nitrogen in this product is apparently not so readily nitrified as that in oilcakes, and even in 8 weeks only about 20 per cent. of the total nitrogen in the material was nitrified. It must therefore be regarded as a much slower acting manure than, for example, castor cake.

Summary.

1. The response to nitrification of some common organic manures has been determined, this being a factor in considering the availability of these materials as manures.

2. Five typical soils widely found in the Central Provinces and Berar were used in this experiment, these soils being subject to varying conditions of climate and cultivation.

3. The nitrogen of castor cake appears generally to be quickly available and *karanja* and *sarson* cakes are not much inferior to castor except in *wardi* soil.

4. Linseed and *tili* cakes come generally next in order of merit and may therefore be considered slower acting manures than castor cake.

5. *Mahua* refuse appears relatively to be a slow acting manure.

6. Groundnut cake does not seem to undergo a rapid decomposition in some soils, but in black cotton soil it is highly nitrified to the extent of 86 per cent. of the total nitrogen in 8 weeks.

7. The nitrogen in *mahua* cake is not nitrified to any appreciable extent during a period of 8 weeks in any of the soils under experiment.

8. Results obtained from *sihar*, a typical rice soil, where the cultivation is of an anaerobic or semi-anaerobic nature for a considerable part of the year, show that the nitrifying power of this soil is much less than that of soils subject to open cultivation.

AVAILABILITY OF THE TRICHINOPOLY PHOSPHATIC NODULE AS A MANURE FOR PADDY.*

BY

RAO SAHIB M. R. RAMASWAMI SIVAN, B.A., DIP. AGRI.,
Government Lecturing Chemist, Agricultural College, Coimbatore.

IN the "Year Book (1918) of the Madras Agricultural Department," a descriptive account of the phosphatic nodules of Trichinopoly has been published. It was pointed out therein that the mineral contained too much of lime and also of iron and alumina to be economically manufactured into superphosphate, and that the best method of utilizing it would be to grind it fine and apply the flour phosphate along with decomposing organic matter to paddy soils most of which, in the Madras Presidency, are deficient in phosphoric acid as revealed by soil surveys. The writer has been carrying on, for the last four or five years, a number of investigations to determine the actual availability of this mineral phosphate under swampy paddy soil conditions. The whole of his work on the subject is being written up, in detail, for a later departmental publication; meanwhile it would be interesting to the delegates of the Agricultural Section of the Science Congress to know something of the results of these investigations.

These investigations included the determination of (1) the solubility of the phosphate in carbonic acid, (2) its solubility in

* Paper read at the Ninth Indian Science Congress, Madras, 1922.

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different strengths of citric acid, (3) its availability as measured by citrate solubility in composts made with green manure and cattle manure, (4) its availability as measured by the growth of paddy plants in pots, with and without green manure, (5) whether increased application of the phosphate gave increased cropping with and without green manure in pots, and lastly (6) its availability as measured by the growth of paddy on a field scale on ryots' lands in conjunction with green manure.

As regards its solubility in carbonic acid and in citric acid, the greater the strength of the acid the more was the phosphate dissolved—a result in consonance with the observations of previous workers.

The amount of phosphate dissolved in ammonium citrate according to the usual official method, *i.e.*, of heating for half an hour at 65°C., was greatest in one week's compost and became less and less in longer kept composts, pointing either to the possibility of the soluble phosphate reverting in the longer kept composts, or the method of analysis requiring modification. Probably both the factors are present, from the fact that there is over 17 per cent. of calcium carbonate in the mineral and that a later method, modified by Dr. Harrison at Pusa, gave increased soluble phosphoric acid on shaking at *room temperature* instead of at 65°C.

The growth of paddy in pots gave decided results. In one series of experiments, the average yield of dry produce was 31 grm. for no manure, 30 grm. for phosphate only, 39 grm. for green manure only, and 48 grm. for green manure and phosphate, indicating that green manure rendered the phosphate available. The soil used for the experiment contained 0·005 per cent. of available phosphoric acid. Contrary to the results of experiments in the United States of America, increased applications of phosphate from 250 to 1,500 lb. per acre gave no increased cropping, and it was then surmised that nitrogen might as well be another limiting factor in the soil. In the next series of experiments, this was found to be actually the case, as will be seen from the following table.

TABLE I.

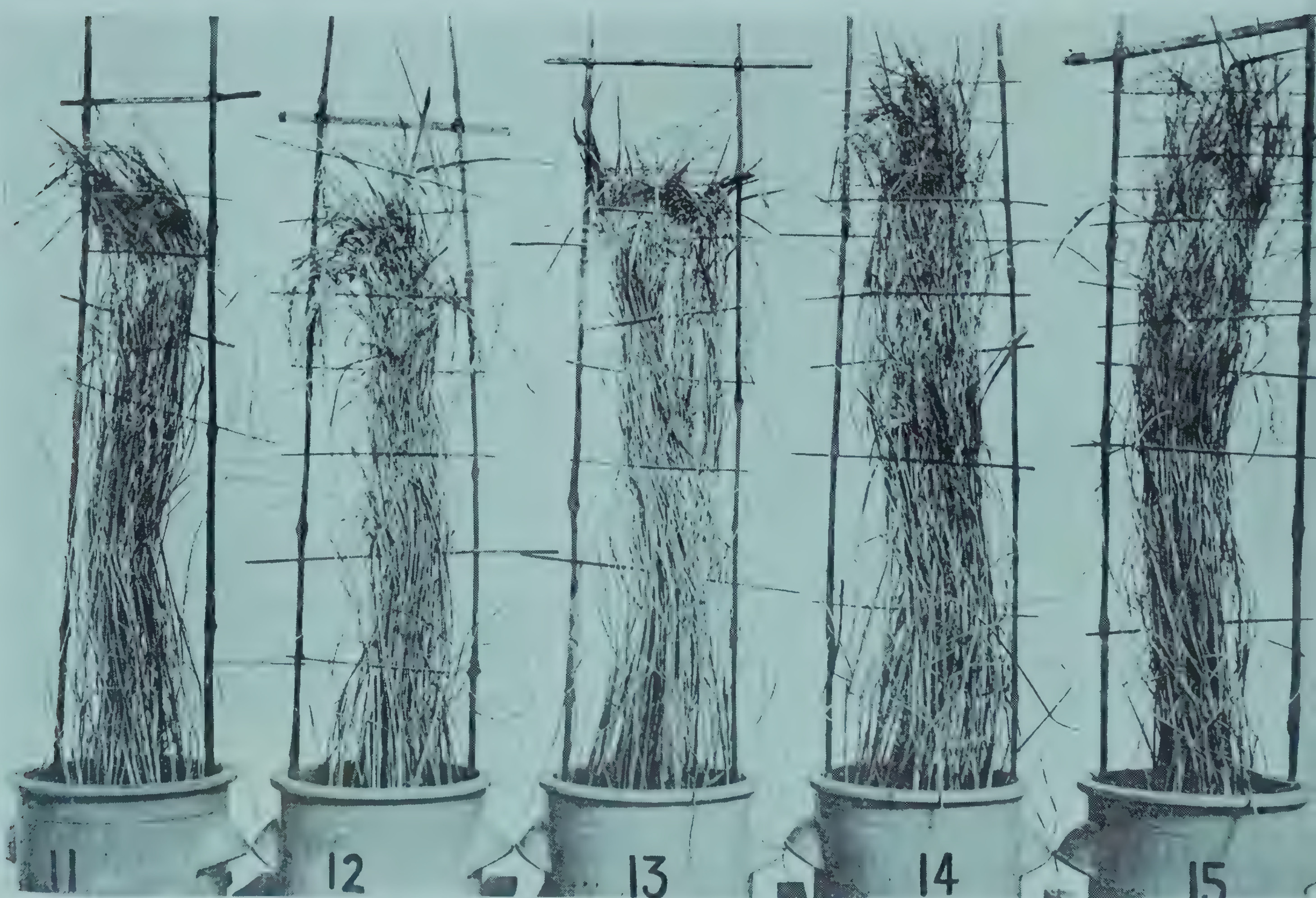
Showing number of tillerings and yield of grain and straw (paddy).

Pot No.	Nature of experiment	No. of tillerings	Weight in grm.		
			Grain	Straw	Total
1	N	28	13·1	20·9	34·0
2	N & P	29	13·2	19·3	32·5
3	N & 2P	30	16·7	21·3	38·0
4	N & 4P	31	18·2	21·3	39·5
5	N & 8P	29	20·6	22·5	43·1
6	nil	19	7·4	13·3	20·7
7	P	30	10·7	15·5	26·2
8	2P	30	11·9	15·2	27·1
9	4P	32	12·8	14·0	26·8
10	8P	30	12·3	12·2	24·5
11	G & N	52	26·8	42·9	69·7
12	G & N & P	60	27·1	47·5	74·6
13	G & N & 2P	62	32·3	47·8	80·1
14	G & N & 4P	62	36·8	53·7	90·5
15	G & N & 8P	68	36·8	56·6	93·4
16	G	39	24·6	28·1	52·7
17	G & P	42	24·7	33·5	58·2
18	G & 2P	47	26·5	33·3	59·8
19	G & 4P	50	28·1	35·2	63·3
20	G & 8P	50	32·4	35·1	67·5

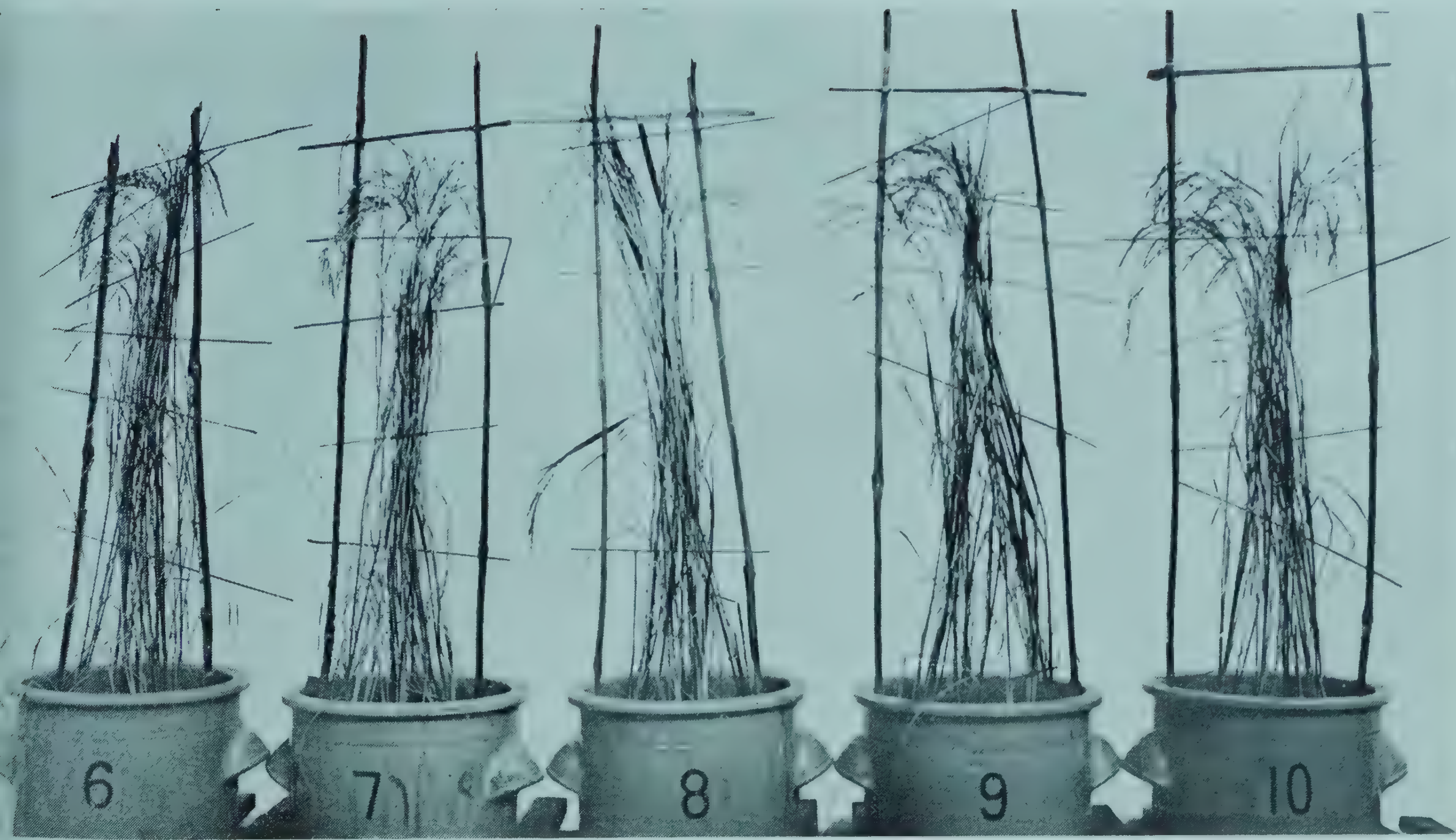
Note. P=250 lb. of flour phosphate. G=5,000 lb. of green *dhaincha* (*Sesbania aculeata*) leaves. N=400 lb. of sulphate of ammonia. (Per acre.)

These results are interesting in several ways. Mere application of phosphate gives lowest yield, but the nitrogen pots yield better, while the green manure pots are better still. The green manure and nitrogen pots, however, are the best. The results also show that, in addition to phosphoric acid, nitrogen is a limiting factor in the soil. Again the phosphate is rendered more available by green manure than by nitrogen in the form of sulphate of ammonia. It is also to be noted that there is a small increase in the yield of crop with increased application of phosphate, though not commensurate with the quantity supplied, in three sets of experiments, pure phosphate plots excluded.

Results obtained at the Manganallur Agricultural Station for several years have shown that flour phosphate is nearly as good as bone meal in giving an increased yield of paddy grain. The experiment was tried in different paddy tracts of the Presidency



Paddy plants in pots manured with sulphate of ammonia, Trichinopoly flour phosphate and



dhaincha leaves separately and in combinations. (For details see Table I.)

with the co-operation of the Deputy Directors. An approximately uniform piece of land, usually one acre, was selected, evenly manured with green leaves, and divided into 10 long strips. Alternate plots received flour phosphate at the rate of 500 lb. per acre.

There was a general increase of 301 lb. of grain per acre in the phosphate-manured plots—the soil of each containing less than 0·01 per cent. of available phosphoric acid—which works out to 11 per cent. over the plots manured with green manure only, as will be seen from the following table :—

TABLE II.

Comparative yields from plots treated with green manure alone and with green manure and flour phosphate.

Locality	Average of 5 experiments (yield in lb. per acre)			Percentage of increase
	Green manure	Green manure and phosphate	Increase in grain	
Ettapur, Salem District (1919) . .	2,138	2,550	412	19
Ditto (1922) . .	3,759	4,060	301	8
Danishpet, Salem District (1922) .	3,603	3,879	276	8
Elandangudi, Tanjore District (1922) .	2,102	2,440	338	16
Central Farm, Coimbatore District (1921)	2,013	2,208	195	10
Ditto (1922)	2,562	2,843	281	11
Average .	2,696	2,997	301	11

From the above investigations, the conclusion is drawn that mineral phosphate, ground as fine as possible, is a suitable phosphatic manure for paddy lands when applied along with decomposing organic matter. The residual effect of the mineral phosphate seems to be very sensible, judged by the experiments at some of the Government agricultural stations, but this is still under investigation.

FURTHER INVESTIGATIONS ON THE *FUSARIUM* BLIGHTS OF POTATOES IN WESTERN INDIA.

BY

HAROLD H. MANN, D. Sc.,
Offg. Director of Agriculture, Bombay ;

AND

S. D. NAGPURKAR, B. Ag.,
Of the Union Agency, Bombay.

In a former publication[1] on the *Fusarium* diseases of potato in Western India, written in conjunction with Mr. G. S. Kulkarni, the results obtained were summarized as follows :—

(1) Dry rot forms by far the dominant disease of stored potatoes in India, seed potatoes from every part of the country being badly affected. In some cases the amount present is so great that storage in Poona in the cold weather for two months at about 80°F. means the loss of over eighty per cent. of the stored potatoes.

(2) The Italian white round potato, grown in Poona and in the Deccan generally, does not rot so easily in stores with this fungus as the thinner skinned kidney varieties grown in the Nilgiris, the Himalayas, and North India generally.

(3) While potatoes with broken skin are infected in the store there is no evidence that mature potatoes with unbroken skin of

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[1] "Investigations on Potato Cultivation in Western India." *Bombay Dept. Agri. Bull.* 102.

the Italian white round variety can be so infected ; all our experiments to secure such infection have failed.

(4) *Fusarium*-infected tubers when used as seed give tubers which while apparently healthy at harvest rapidly become damaged by dry rot and hence rapidly decay in storage.

(5) Tubers grown in infected soil rapidly decay on storage. The soil remains infected for three months at least. After eight months, in one experiment, infection was not obtained, but this cannot be regarded as conclusive.

(6) With these results, the use of infected seed, however slight the infection may be, must be regarded as perpetuating the disease though it may not apparently give a lower yield or unhealthy plants in the field. To obtain good seed, the potatoes must also be planted in soil which has not recently borne a crop liable to this disease. Eight months is the minimum time required for the soil to free itself from infection, and it may need much more.

(7) *Fusarium* wilt, leading to dying of the plants in the field, also occurs in the Deccan area. Its relationship to the dry rot which is so common is not known, but when a tuber from a wilted plant is grown, the tubers which are produced are rapidly attacked, by what is apparently dry rot, in storage.

These provisional results obviously needed confirmation and extension, and the experiments now to be detailed were designed in order to give light on this disease which, in India, is one of the most serious of those attacking potatoes in storage, while at the same time an important blight of the plant in the field.

The potatoes which are attacked by *Fusarium* show the attack in one of two forms. There may be, on the one hand, typical dry rot (*khokha*). In this there is a softening of the skin (generally on the stem end of the tuber), with a slight depression. The skin may or may not split at this point. If it does, the hole so produced enlarges and the potato is gradually eaten up by the fungus, leaving a brown residue. If it does not, the potato gradually shrivels, and ultimately remains as a shrivelled mass of hard brown matter. On the other hand, the attack may not be obvious on the outside, but on cutting open the potato there may be a ring

of brown matter, which at the first sight is very similar to the appearance characteristic of the bacterial ring disease (*bangdi*). The similarity to the bacterial ring disease is quite superficial, however, and the two diseases can be easily distinguished by the following differences :

Bacterial Ring Disease.	*Fusarium Ring Disease.*
(*a*) Ring is dark in colour and soft.	(*a*) Ring is brown in colour and hard.
(*b*) When potatoes are cut open and pressed, pus exudes from the ring.	(*b*) When potatoes are cut open and pressed, no kind of pus exudes.
(*c*) Under the microscope millions of short rod-like bacteria are found in a drop from the ring.	(*c*) Under the microscope crescent-shaped bodies are noticed in material taken from the ring.
(*d*) When affected potatoes are used for seed the plants always wilt and die.	(*d*) When affected potatoes are used for seed the plants sometimes die but often give apparently healthy grown tubers.
(*e*) The affected growing plants die almost always in the first month.	(*e*) The affected growing plants keep on dying throughout ; most die in the last month before maturity.
(*f*) The eye of the potato is injured and its germinating power destroyed.	(*f*) The eye of the potato does not undergo special injury.

Whether the *Fusarium* which forms the *khokha* dry rot and that which produces the ring as above described are the same species is not yet entirely clear. But the experiments which follow are done with material which in each case is completely defined and hence conclusions can be drawn with confidence.

The points we have endeavoured to settle are six in number and they may be dealt with in succession.

A. *What is the effect of temperature on the attack of Fusarium both on plants in the field and on tubers in store ?*

So far as plants in the field are concerned, the test was made by planting sets, affected with *khokha*, in plots (twenty sets per plot), at monthly intervals from June 1919 to February 1920. It is well known that at Poona, where these experiments were done, the temperature from June to September is moderate, higher in October, after which it remains low till February. Then the

temperature rapidly rises, till in April it may reach a shade maximum of 105° to 110°F. The results are indicated in the following table :—

Plot	Time of planting	Time of harvesting	Condition of plants at harvesting
(*a*)	June 15th ..	September 15th ..	All healthy.
(*b*)	July 15th ..	October 15th ..	One plant drooping. Rest healthy.
(*c*)	August 4th ..	November 4th ..	Three plants drooping. Rest healthy.
(*d*)	October 15th ..	January 15th ..	One plant drooping. Rest healthy.
(*e*)	November 5th ..	February 15th ..	All healthy.
(*f*)	December 15th ..	March 15th ..	All healthy.
(*g*)	January 15th ..	April 15th ..	Two plants dead. Rest became very pale in colour at an early stage.
(*h*)	February 5th ..	May 5th ..	Thirteen plants dead.
(*i*)	February 20th ..	May 20th ..	All plants became pale and began to die within 66 days.
(*j*)	(Sound tubers) February 20th ..	May 20th ..	All plants healthy but weak. Tubers produced were very small.

The damage done to the growing plants by the *Fusarium* infection in the seed is clear and its correlation with the temperature is equally obvious. The higher temperatures from February to May are obviously unfavourable to potato, but sound sets gave plants which could mature. But plants from infected seed which were in the ground in October or in April or May were badly infected and many died. The higher the temperature during growth, in fact, the greater the virulence of *Fusarium* attack on the growing plant. This agrees with the experience in the Khed (Poona) tract in 1918-19 (a famine year) when the temperatures were very high. Again in 1920, seed from Italy came very late, and was planted from the latter part of January to the end of February. The early sown sets gave a fair crop ; the later, though from the same seed, were so badly attacked by *Fusarium* in the field that the crop was almost destroyed.

The relationship of the damage to the stored tubers to the temperature has been shown by the rapidity with which *Fusarium* attack (*khokha*) spreads in potatoes after importation from Italy

to Bombay. A cargo of seed potatoes reached Bombay on January 14th, 1920.* Immediately on arrival the whole contents (7,000 lb.) of fifty bags were examined. 77 potatoes (weighing 18 lb.) were found to be attacked with *khokha* (0·26 per cent.). A week only later, 150 lb. (2·14 per cent.) from a similar quantity of potatoes were obviously suffering from the same disease. Under the temperature conditions of Bombay the amount of obvious attack had increased over eight times in one week.

High temperature whether in the field or in the store is therefore very favourable to *Fusarium* attack, and it is obvious that if infection is present in the sets (as it almost always is), or in the soil, the choice of a cool season for growing the crop, or any success in lowering the temperature of the store, will reduce very much the loss due to the class of fungi under discussion.

B. How are potatoes infected with Fusarium in the store?

As indicated in the summary of previous results given above, direct infection in store of potatoes with unbroken skin from one to another seems very uncommon. We can go further than this now, as a result of the following experiment.

Five glass boxes were prepared, each containing a sound potato and a potato infected with *khokha* in contact, and these were kept from January to the end of March 1921. In no case was the sound potato found to be affected at the end of the period in spite of the high temperature. Five glass boxes were also prepared at the same time, each containing a potato, cut open, in contact with a potato infected with *khokha*. In this case also, none of the sets from sound tubers became infected. A third similar set was prepared in which tubers attacked by potato moth (*Phthorimæa operculella*) were placed in contact with tubers attacked with *khokha*. In

* Temperatures in Bombay in January and February are as follows :—

	Extreme maximum shade temperature	Mean maximum shade temperature	Mean shade temperature
January	91·0°F.	79·7°F	73·9°F.
February	96·2°F.	82·1°F.	75·0°F.

this case in three boxes out of five infection resulted, and the moth-infected tubers became attacked with *Fusarium* (*khokha*).

This experiment is important because it accounts in part for the wholesale and rapid way in which heaps of potatoes in store in the Khed (Poona) tract are destroyed by dry rot ; it also explains why fumigated potatoes keep so much better, so far as rot (*khokha*) is concerned, than those which have not been fumigated. There is hardly, in fact, a heap of potatoes in the above tract which does not contain moth-attacked potatoes, and hence infection in such a heap spreads very rapidly. Fumigation, by destroying the moth, reduces the chance of a sound tuber being infected by the rot.

C. How is the germination affected by the presence of Fusarium *in the tubers?*

In the former publication, it was shown how the potato cultivators of the Deccan sometimes prefer seed potatoes slightly attacked by *Fusarium*, because they are said to germinate more rapidly than those which are free from the disease. This opinion of the cultivators appeared to be correct from preliminary experiments there recorded. Further evidence in the matter has now been obtained. Seed potatoes were taken, affected with *khokha* to a varying extent, from an obvious patch in the tuber about a quarter of an inch in diameter to a case where most of the surface was shrivelled.

Placed in the order of extent of *khokha* attack in the seed, *six* sets of each type gave results in speed of germination as follows :—

	Number of sets with plants above ground				
	After 8 days	After 15 days	After 30 days	After 45 days	Total
Sound seed	0	1	3	2	6
Very slight attack	1	1	2	2	6
Slight attack	2	1	2	1	6
Half surface affected	2	1	0	0	3
Three quarter surface affected ..	1	1	0	0	2
Almost all surface affected ..	1	0	0	0	1

Thus it appears that in every case the proportion of the sets attacked with *khokha* which germinated within a week or even

within a fortnight was greater than that with sound potatoes. This confirms our previous experience and also the opinion of the potato growers. All the sets which had less than half the surface attacked were able to germinate, but the spread of the *Fusarium* attack beyond this point led to the destruction of the germinating power of a large proportion of the seed potatoes.

D. How does Fusarium attack generally originate in a growing crop?

It has usually been stated that the most general source of *Fusarium* infection in potato tubers or potato plants is the soil in which they are grown, while the seed forms a less important source of the disease. To determine this question under our conditions in the Deccan in the *kharif* season, potatoes were grown in pots from June 30th to October 4th, 1919. The soil used was fresh, and had not borne a crop before. Five pots were taken. These were treated as follows :—

(1) The soil was untreated and the seed was sound.

(2) The soil was untreated and the seed was slightly affected with *khokha*.

(3) The soil was untreated and the seed was sound, but the sets were cut with an infected knife.

(4) The soil was watered with water in which *khokha*-infected potatoes had been crushed, but the seed was sound.

(5) The soil was mixed with fragments of *khokha*-infected potatoes, but the seed was sound.

Each pot was planted with three sets and the number of potatoes produced at harvest with the amount of infection at that time was as follows :—

No. of pot	Number of potatoes harvested	Number of diseased potatoes at harvest	Number of sound potatoes harvested
1	13	0	13
2	14	3	11
3	11	0	11
4	7	0	7
5	15	1	14

At harvest therefore it is clear that the only attack was in the cases where (1) infected seed had been used and (2) where the soil had been mixed with fragments of infected potatoes. In the others there was no sign of infection. The produce was kept in store for three months, and still only in the cases just stated did any disease supervene. In other words, the cutting of the sets with an infected knife totally failed to produce disease, and the same was the case where the soil was watered with water in which *khokha*-infected potatoes had been crushed. In the other two cases, however, the attack was progressive and the following table shows this progress. The potatoes already attacked were removed at each examination.

	Produce from infected seed	Produce from soil mixed with infected potatoes
Total potatoes at harvest ..	14	15
Attacked at harvest ..	3	1
Additional attacked		
(*a*) after one month ..	4	3
(*b*) after two months ..	2	4
(*c*) after three months ..	1	0
Total sound potatoes after 3 months	4	7

The result of this experiment seems very clear. Infected sets produce potatoes which are diseased in over 70 per cent. of cases. Soil mixed with diseased tubers produce potatoes which are diseased in 53 per cent. of cases. Apparently infection through the knife used for cutting the sets or through watering the soil with infected material is much more difficult.

E. How long does infected soil remain capable of producing disease in potatoes grown on it?

Though the last experiment would seem to indicate that infection through the soil is not so certain as through the use of infected seed, yet the soil *is* capable of transmitting the disease. The question becomes, therefore, important as to the length of time such soil remains infective. Five small plots were therefore

taken in each of which ten sets were planted in June (15th) 1920. The crop was harvested on September 25th. The soil had been carefully and thoroughly infected by mixing with fragments of *khokha*-infected potatoes, in the case of plot (*a*) three months before, in (*b*) six months before, in (*c*) nine months before and in (*d*) twelve months before. Plot (*e*) was a check plot in which no infection had been made.

The results were very interesting and clear.

	a Soil infected 3 months before	*b* Soil infected 6 months before	*c* Soil infected 9 months before	*d* Soil infected 12 months before	*e* Fresh soil
Number of tubers harvested ..	32	17	23	39	29
Number of diseased tubers at harvest	9	6	4	0	0
Number of additional diseased tubers after two months' storage ..	13	7	2	0	0

The soil therefore remains very infective after three months, nearly 70 per cent. of the tubers becoming diseased. The same was the case after six months when about 77 per cent. were attacked. After nine months the attack is much less, only 24 per cent. of the tubers becoming diseased, while after a longer period no infection resulted. It would appear, therefore, that if land remains unoccupied by potatoes (or by another crop susceptible to the disease) for twelve months under Deccan conditions, it is not likely to cause *Fusarium* attack in the crop then grown.

F. When tubers are attacked with Fusarium, does the time at which they are harvested affect their keeping quality?

This matter is important, especially in an area like Western India where almost all the available seed is more or less infected. Even the seed imported from Italy contains much of this disease. Hence the question as to whether the keeping quality of the produce can be affected by altering the time of harvesting is one which cannot be neglected.

Five small plots on new soil were laid out, and in each ten sets were planted. In four of these plots all the sets planted were slightly affected with *khokha*, and the crop after growing was harvested at different stages as follows :—

(1) Harvested while the plant was still wholly green, 84 days after planting.

(2) Harvested when the top had turned pale, 90 days after planting.

(3) Harvested when the plants had become wholly yellow, with some leaves drying, 100 days after planting.

(4) Harvested when plants were wholly dried, 110 days after planting.

(5) Check plot, with fresh seed free from disease, harvested when dead ripe, 110 days after planting.

The crop grew from June 15th to September, plots (1), (2), (3), (4) and (5) being harvested respectively on September 7th (1), September 15th (2), September 25th (3) and October 9th (4 and 5). All the harvested potatoes were then kept till the end of November, and the following notes were made in each case.

Plot 1. All the plants were healthy in the field and all the potatoes were sound at harvesting. After 84 days' storage two potatoes out of 27 showed signs of *khokha* attack (7·4 per cent.).

Plot 2. One plant showed signs of drooping before harvest, but all the potatoes dug up appeared sound. After 76 days' storage, seven potatoes out of 31 showed signs of *khokha* attack (22·6 per cent.).

Plot 3. Three plants showed signs of drooping before harvest and two potatoes were affected with *khokha* at the stem end at the time of digging. After 66 days' storage, a total of 13 potatoes out of 25 harvested showed signs of *khokha* attack (52 per cent.).

Plot 4. Two plants showed signs of drooping before harvest, and three potatoes were affected with *khokha* at the stem end when dug. After 52 days' storage, a total of 22 potatoes out of 37 harvested showed signs of *khokha* attack (59·4 per cent.).

Plot 5. All were sound and remained sound throughout.

It seems safe to conclude that early harvesting is advisable in the case of potatoes known to be affected with *khokha*, as the loss in storage increases rapidly if the plants are allowed to ripen in the field.

G. *What is the connection between the two forms of Fusarium attack, namely, the dry rot (Khokha), and the wilt in the field associated with the presence of a brown Fusarium ring in the tubers?*

It is not pretended that the connection between these two forms is entirely cleared up, nor can it be until a full mycological examination of the fungi involved has been completed, but the observations made may be found of value.

The ultimate fate of potatoes attacked in the two ways is different and may be described as follows :—

(1) When a plant is attacked by *khokha* or dry rot, the first depression is usually at the stem end of the tuber. This gradually cracks and opens out, the opening becoming wider and wider. On the surface, wrinkles are formed which widen and extend. The potatoes become hollow and dried up, but in no case of simple *khokha* attack has any form of wet rot been observed, and the potatoes with pure *khokha* do not give an offensive smell at any stage.

(2) In the case of tubers affected by the 'ring' form of *Fusarium*, a number were kept, each in a separate glass-covered box, and were stored from December 4th to the end of the following February. Throughout this period the potatoes did not rot except in one case where a slight depression occurred as in *khokha*, though even here it did not extend during the period of observation. The other potatoes were not obviously rotting throughout the time.

From these observations it will be seen that when the internal form of attack, which we have termed the 'ring' form of *Fusarium*, occurs, it may persist through the whole of the storage period and infect the following crop without being detected at least until the sets are cut.

A number of potatoes (10) showing signs of 'ring' *Fusarium* were planted in July 1920 and watched separately. All germinated in due course and gave plants which appeared above ground within a fortnight. All grew vigorously for the first 22 days, but after 37 days one plant showed signs of weakness. A fortnight later (52 days) another plant was noted as weak. Both of these gradually drooped and at the time of harvest (after 78 days) these as well as a third plant (which was suddenly attacked) were dead of what was then identified as *Fusarium* wilt. This was 30 per cent. of the total plants. The remaining plants gave 24 potatoes of which one showed signs of *khokha*. After two months' storage these tubers showed (1) in four cases signs of *khokha* (dry rot), (2) in three cases a distinct *Fusarium* ring in the potato, and (3) in one case an attack by both forms of *Fusarium* at the same time. The remainder still appeared quite sound.

SUMMARY.

The experiments here quoted, though they cannot be regarded in most cases as absolutely conclusive, do give very strong evidence which will enable the attack on this serious fungus disease of the potato to be made with a good chance of success.

In the first place, they emphasize the importance of infected seed as the principal source of continued infection. The soil may also convey the infection, but apparently it must be actually mixed with potato tubers containing the disease if it is to infect a new crop. The soil remains infective for nine months at least, but after twelve months seems no longer to be able to infect sound potato tubers used as seed.

This being the case, we can concentrate our attention on the way in which the seed becomes attacked. The experiment seems to show that the disease rarely, if ever, passes directly from one tuber to another, even if they are cut, but if the caterpillar of the potato moth (*Phthorimœa operculella*) is present in the stored tubers infection easily takes place. This is important, and is a new reason for fumigating all potatoes intended for seed before they are stored.

The opinion held by the potato growers that *khokha*-affected potatoes germinate more quickly than others is confirmed.

The effect of using *Fusarium*-attacked seed is not always noticed at the time of harvest, and it is only when the potatoes are stored that the full effect is seen. During storage, as also among the growing plants in the field, the extent of the damage is largely determined by the temperature. A high temperature increases the rapidity of attack very much indeed, and makes it impossible to grow plants from the infected seed at certain times of the year in the Deccan. As most of the seed used here, including that imported from Italy, *is* infected with *Fusarium* in one form or another, and the soil *may* be infected, the importance of choosing a cool season for growing the crop, and, if possible, also for storing it, is obvious.

While the *khokha* form of the disease leads to complete rotting of the tubers, that occurring as a ring in the potato does not by any means always do so, and may exist in a stock of seed potatoes without being detected at all, or at least only at the time of cutting the sets. Thus it may pass on from generation to generation, and may produce the 'dry rot' form in the crops where it has been used as seed.

The importance of developing strains of pedigree *Fusarium*-free seed seem, therefore, clear, and it is on these lines that the mastery of this most serious disease in Western India will, we think, be accomplished.

ORANGE GROWING IN THE SHAN STATES.

BY

T. D. STOCK, B.Sc., D.I.C., A.R.C.S.,
Deputy Director of Agriculture, Burma.

The oranges of commerce in Burma are produced largely in the Northern Shan States of Theinni and Hsipaw, and the Southern Shan States of Monkung and Kehsimansan, where, in the low-lying and sheltered valleys, the climatic conditions are sufficiently favourable to allow of the crop reaching a certain degree of perfection. Unfortunately, the cultivation as carried on is somewhat primitive : modern methods are not understood and the gardens are neglected. Even under these conditions the crop becomes a profitable one, and although the available area of suitable land may to a certain extent be limited, there is yet ample scope for development on lines of increased production.

This note is the result of a short visit made to the Hsipaw State at the end of 1921, and refers specifically to the cultivation of oranges in the near neighbourhood of Hsipaw town.

Situation and climate.

Hsipaw lies at an altitude of about 1,400 feet in the Namtu valley which opens out here to form a fairly extensive stretch of level paddy land. It is shut in by ranges of hills which tend to make the Hsipaw valley one of the hottest places in the Shan States.

During the hottest months of the year, however, the daily range of temperature is fairly wide : in April the average maximum is about 96° F. and the minimum for the same period about 65° F,

In the cold weather the temperature falls as low as 44° F., and at this time of the year a dense wet mist descends and hangs over the valley during the earlier hours of the morning, obscuring the sun until about 10 A.M., when the mists disperse and the thermometer gradually rises to an average maximum temperature of 75°F. The average rainfall over the last four years works out at 50·48 inches, but this figure is somewhat inflated by the somewhat exceptional fall of 68·75 inches for 1921.

SOILS.

Above Hsipaw town the Namtu river is joined by the Nam Yao and the Nam Ma. The former flows through limestone country which is unsuitable for orange cultivation : the latter, however, brings down quantities of silt, and it is on the silt soils of the Nam Ma and Namtu that the gardens are situated. These soils may be described as light loams, rich in food material, open in texture, and of good depth. In seasons of high rainfall they are occasionally flooded for short periods and so receive a fresh deposit of silt. Sudden rises in the river never last long and the rapid subsidence quickly drains off excess water from these light soils, so that there is rarely anything approaching a state of water-logging. The trees apparently take no harm from the temporary rises in the water-level, while on those rare occasions when the land is actually flooded, they undoubtedly derive a certain benefit in the form of organic matter of which they receive little or nothing at the hands of the cultivator.

VARIETIES.

The gardens are made up mainly of *Citrus Aurantium*, a fair sized orange of the *Santara* type—loose-skinned, mamillate, and rich golden colour : the pulp is slightly acid but sweet and luscious. Two other varieties occur sparingly scattered amongst the trees of the *Santara* type :—(1) *Citrus Aurantium*—Keonla type ??—a fair sized orange, tight-skinned, non-mamillate, and golden yellow colour, sweet but slightly bitter in flavour ; and (2) *Citrus Medica*— a large globose yellow variety with very acid pulp.

Propagation.

These varieties are all grown from seedlings or rooted cuttings. In the growing of seedlings special nursery beds are very rarely prepared, the seed usually being sown thickly in any odd corner of the garden, and the crowded plants left very much to fend for themselves. Occasionally they are transplanted, but the more common practice is to leave them where they were sown for two years, before transferring them to their permanent quarters.

To obtain rooted cuttings operations are commenced in the month of June or July. A suitable branch about $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter is then selected and a ring of bark about 3 inches wide removed at a point 3 to 4 feet from the apex. Moist earth and manure is applied to the barked area and the whole tied round and supported with bamboo splits. The impact of the moist earth against the barked surface induces the formation of adventitious roots, and by November the rooted layers can be cut off and planted out.

Cultivation.

Cultivation is simple in the extreme. After selecting a suitable site the land is cleared and the surface worked to a depth of 6 inches. Holes are prepared in the month of September 15 feet apart, 2 feet deep, and about 9 inches in diameter, and left until the following November, the time when planting usually takes place. Either rooted cuttings or seedlings may be employed, the general custom being to plant at the rate of two rooted cuttings to one seedling. A single plant is placed in each hole which is then half filled with good rich loam. It is only rarely that manure is applied, either at the time of planting or at any subsequent period.

In young gardens the ground is sometimes utilized for the cultivation of winter vegetables, excellent crops of these being grown without very much trouble. After the sixth or seventh year, however, the overhead shade interferes with the successful cultivation of surface crops, and from this period onwards the ground merely receives an annual ploughing, followed by occasional workings to keep down growth of weeds.

Apart from the occasional cutting out of dead branches and parasitic growths of *Loranthus,* no pruning is practised, the trees being allowed to grow very much as they choose.

Commencing in February, water is supplied at intervals of four days and continued until the breaking of the rains in May or June. No system of irrigation has been developed, the whole of the water being carried from the river and applied at the rate of one kerosene tin per tree every five days. Much of this water is wasted as it is applied to the bole of the trees where little of it becomes available to the roots and no attempt made to conserve it in the soil.

The crop.

It has already been observed that in planting two rooted cuttings are employed for every seedling. The reason for this is obvious. The former commence bearing in the fifth year, attain their maximum output between the ninth and fifteenth years, then gradually decline and are hardly worth retaining after the twentieth year. The seedlings on the other hand do not come into bearing until the eighth or ninth year from which time they retain their bearing qualities unimpaired until the sixtieth or seventieth year.

In gardens which have been planted largely with rooted cuttings it is quite a common practice to inter-plant after the twelfth year with younger trees. These come into bearing and replace the older trees when the diminished yield of the latter makes them no longer worth retaining.

The crop is harvested in the months of November–December. There is apparently a great deal of variation in the outturn of different trees in the same year, and of the same tree in different seasons. I am given to understand that a good tree in a favourable season is capable of producing over 100 *viss* (365 lb.) of fruit, but this is invariably followed by a season of low output. The local price for the *Santara* loose-skinned variety is about Rs. 20 per 100 *viss*: other varieties fetch only Rs. 5 to Rs. 6. The fruit is packed in locally made bamboo hampers and sent down to Burma where they find an excellent market.

Lines of improvement.

In spite of the somewhat crude methods adopted for the cultivation of oranges in the Shan States the profits accruing are considerable, and in suggesting certain lines of improvement it is not so much with a view to increasing these profits as to lessening the price to the consumer by assuring a bigger output.

Propagation. The benefits derived from budding are so well known that it almost demands an apology to mention them again here. The main object is to produce a strong hardy plant with rapid growth, and to effect this the stock should be of a variety naturally hardier and more vigorous than the variety to be budded. In the Shan States these qualities are found in varieties of *Citrus Medica*, and experiments might be carried out to determine the effect of budding on this stock as also on the *Jamburi* (*Citrus Medica* var.) stock so commonly employed for the purpose in parts of India.

Uniformity in quality and size can hardly be expected from seedling oranges. The employment of budded stocks would be followed by a general improvement in the quality of the crop, as the range in quality and size, which is so pronounced a feature of Shan oranges, would tend to disappear as a result of using buds from trees of recognized quality, or it may be from one tree of superlative merit.

Lastly, the grower would not only obtain a hardier tree and better fruit, but would combine in the budded stock the earlier bearing qualities of the rooted cutting with the longer life of the seedling.

Cultivation. Bumper crops over a succession of years can hardly be expected with anything approaching regularity. Nevertheless, an orange tree, if properly grown and well cared for, might be counted upon to produce an average crop in most years. This rarely happens in the Shan States where a good crop is invariably followed by one of meagre dimensions. That this is not due to climatic or seasonal conditions is indicated by the fact that depression applies in any year to particular trees only, and not to the crop as a whole. The trees become exhausted and this undoubtedly

is due to the scant attention which they receive. The incorporation of well rotted manure at the time of planting, and an annual surface dressing of the same material, should do much to improve the irregular cropping.

The surface dressing would also serve to conserve moisture in the soil during the dry weather, and might be the means of cutting down the supply of water, the carrying of which throughout the dry weather calls for an enormous amount of labour. Whether some system of irrigation might profitably be employed is a question which can only be decided in reference to each particular area. In any case a circular bed—small at first and increasing in size as the roots spread further out—should be adopted for irrigation purposes in place of the present system of pouring a kerosene tin of water round the bole of each tree every five days.

Pruning. Apart from cutting out dead wood and parasitic growths of *Loranthus* no pruning is practised and the trees become masses of weak stunted growth rising on many stems from the ground upwards. Under such circumstances they can hardly be expected to do their best. It must be recognized of course that judicious pruning demands knowledge, and until the grower is equipped in this respect, it is better that he should restrict his operations than blindly attack trees which after all are not doing badly.

Cropping. One other point presents itself and it is one which in view of increased production will have considerable importance. The market for the Shan oranges is a local one and to a certain extent limited. To what extent increased production might affect this market is at present difficult to say, but, were the period of production extended to cover the hot weather months, it is safe to assume that ample scope for development would be offered. The orange tree responds very readily to care and attention, and by foregoing the ordinary crop and utilizing the blossom of the early rains, fruit might be obtained to ripen during the months of March and April. Whether this would prove a profitable procedure, however, cannot be definitely stated, but a field is opened up for experiment and trial.

The establishment of a small experimental garden to supply growers with budded stocks, to introduce modern methods and carry out experimental cultivation would do much to develop the commercial possibilities of orange cultivation in this area.

A CAUSE OF STERILITY IN RICE FLOWERS.*

BY

R. K. BHIDE,

Offg. Plant Breeding Expert to Government, Bombay.

DURING the last few years, the writer has frequently observed that, in certain varieties of rice in Western India, there is a persistent appearance of a number of unfilled glumes in the ears, interspersed with perfectly well developed grains. In two or three types this tendency to the occurrence of empty glumes is very remarkable. One of these in Kanara is called *bille bhatta*, a late variety which takes no less than 140 days from sowing to flowering. A still more marked case is a strain of the *kamod* variety of Nasik. This strain has been suspected of being a cross between the scented *kamod* and an inferior type, but there is no direct evidence of such being the case. It has, however, lost the deeper colour of the husk and the fineness and smell of the grain which is peculiar to *kamod*, and always, wherever grown, has particularly infertile ear-heads. A third instance is still more remarkable. An artificial hybrid between a local starchy variety in the Konkan, termed *botka*, and *black* rice, a glutinous type derived from Burma, gave a first generation cross which proved to be totally sterile. This total sterility was accompanied by an extraordinary vegetative development, one plant producing no less than fifty to sixty tillers. Most of the tillers flowered, but no grain whatever was produced.

Less marked cases than those quoted are very common. In the variety in which most of our breeding work has been done in the Konkan—the *kolamba* variety of the Thana and Kolaba

* Paper read at the Ninth Indian Science Congress, Madras, 1922.

Districts in the Bombay Presidency—many of the strains always possess a number of unfilled glumes in the ears. It has been customary to attribute this, without direct evidence, to unfavourable weather conditions during flowering, but it has for some time been suspected that the cause lay deeper than this, as it is difficult to see why unfavourable weather conditions should affect the fertilization of certain flowers in the panicle only, the others being quite normally developed.

During the past season further evidence on the point has been obtained. One of our *kolamba* strains at Karjat produced a variant which was totally sterile. Its sterility was not due in this case to unfavourable weather conditions, to excessive vegetative development, to the attack of the rice stem borer (*Schœnobius bipunctifer*), or to the fungus (*Sclerotium Oryzæ*) which often causes the panicles of rice to be sterile. The sterility was in fact definitely due to the contabescence of the anthers.

This variant was a poor specimen from the beginning. It was a shorter and more delicate plant and had fewer tillers and much smaller spikelets than the type of the strain among which it occurred. The ear appeared above the sheath at the same time as in the case of other plants (8th October, 1921), but fertilization did not take place owing to the impotence of the anthers. The panicles were somewhat compact as compared with those in other plants, and there were a few small rudimentary spikelets at the tips which lacked chlorophyll. The remainder of the ear remained green for a very long time ; the filaments grew very slowly, and the glumes never opened. On microscopic examination the anthers showed pollen grains almost entirely collapsed and with little or no contents. Neither the anthers nor the pollen showed the characteristic yellow colour which is generally seen in a normal rice flower before the glumes open. The ovary appeared normal, although there was no grain formation.

Two more similar variants, showing complete failure to fertilize the flowers, have appeared in the crop of 1921. Of these one was found in another strain of the *kolamba* variety and the other in a still finer variety.

The writer is of opinion that the plants described cannot be due to accidental mixture, nor can they be first generation hybrids, as the flowers from which the seed was obtained were carefully bagged. Furthermore the spikelets in these varieties were smaller than in any rice with which he is acquainted.

The existence of such variations strengthens the suspicion that failure to form a complete ear of grain is not always due to unfavourable environment, but may be due to malformation and incomplete development of the pollen, and that this is a hereditary quality. If this is true, the tendency to form partially empty ears is one of the factors against which a plant breeder in the case of rice must carefully guard himself. Total sterility, as such, is only dangerous when the flowers are pollinated by normal pollen from other flowers, but a strain which contains a factor leading to the maldevelopment of the pollen may be the source of very considerable loss.

Selected Articles

SELECTION OF VARIETIES IN CANE CULTIVATION.*

BY

C. A. B.

THIS paper[1] by F. S. Earle is the last of a series of three published in the same Journal.[2] In it he summarizes all the information he has collected regarding canes grown in Porto Rico, but besides this he presents his matured opinion upon the whole subject of the classification of sugarcanes and, as is usual with him, treats in separate sections of such subjects as he considers to be connected with his main thesis. It is with this adventitious matter that we propose to deal in the present note.

It is a fortunate circumstance that the author has been able to publish this long paper of 141 pages before taking up an entirely new line of work, in which we are told that the opportunities for writing will be much restricted if not entirely suspended. Earle's work on sugarcane and other crops[3] has always been distinguished by broadness of view and singular conciseness and clarity of expression and if, as appears to be the case, his disappearance from among the contributors to the *Porto Rico Journal of Agriculture* is connected with the incessant changes of personnel so characteristic of the Department of Agriculture in the island, it is a serious

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* Reprinted from the *Int. Sugar Jour.*, 1922, XXIV, pp. 236–239.

[1] Earle, F. S. "Sugarcane varieties of Porto Rico, II." *Jour. Dept. Agri. Porto Rico*, V, 3, July 1921 (issued 1922).

[2] "Sugarcane varieties in Porto Rico," *l.c.*, III, 2; and "An Annotated List of Sugarcane Varieties," *l.c.* IV, 3.

[3] For an example see "Southern Agriculture," 1908.

indictment of the futility and viciousness of that policy.[1] Both of the other papers of the series have been noted in this Journal. From the first we extracted a note on the " Question of Policy in the Selection of Cane Varieties,"[2] and the second received a longer notice under " Recent Cane Agriculture."[3] In the present paper the first 40 pages are devoted to various subjects which, in their turn, have been more or less the questions of the hour in cane cultivation and, although obviously dominated by his intimate knowledge of conditions in Cuba and Porto Rico and perhaps primarily intended for Porto Rican readers, the summaries given are worthy of the attention of a wider circle. These then we shall pass under review, although the author's habit of using few unnecessary words makes abbreviation difficult and often does not do full justice to his line of argument.

Foreword. The importance of the selection of the proper variety for each tract, if not for each field on an estate, is now generally conceded in the industry. But the author points out that little has been done to put it into practice. The average planter only too often plants his favourite cane in all kinds of soils and under all sorts of conditions, while in Porto Rico it is the almost universal practice to plant a miscellaneous mixture of canes in the same field. Besides the question of obtaining a crop of evenly maturing canes, this mixing is of specially serious import as regards pests and diseases in that the different kinds vary greatly in their resistance. " This careless custom is costing Porto Rico literally millions of dollars annually." In every important sugarcane growing country in the world, the industry has been threatened at one time or another by the sudden appearance of some plague, and aside from strictly preventive methods no practical remedy is known for any sugarcane disease, except that of substituting some more resistant kind. When once this fact was appreciated, great collections began to accumulate in the experiment stations of many countries and exhaustive trials were commenced with these. Then came the discovery of the fertility of

[1] *Int. Sugar Jour.*, 1921, p. 610. | [2] *Int. Sugar Jour.*, 1921, pp. 16–17.
[3] *Int. Sugar Jour.*, 1921, p. 450.

cane seed and the interest in the new kinds thus produced relegated the older kinds into the background before their ranges of adaptability had been thoroughly investigated or their botanical characters determined. This was doubly unfortunate, both because no new kind has yet been discovered of equal yield and richness with the old canes which had dominated the cane-growing world for so long, and also because the old forms naturally form the basis on which the new kinds have been raised.

Deterioration of cane varieties. Earle is a convinced believer in the old varieties and argues with great force that it is the soil that has deteriorated and not the varieties themselves. He claims that the Otaheite when grown under the same conditions as it was a hundred years ago, as in some parts of Cuba, does not appear to have changed in its essential characters and gives the same fine yields as it did of yore. It is a cane adapted to a narrow range of conditions, namely, a well aerated soil abundantly supplied with vegetable matter. When it became necessary to plant it on soils compacted by long usage and with the humus and other elements of fertility partially exhausted, it failed miserably, as the root system was not adapted to such conditions. The soil has deteriorated and not the Otaheite, and it affords a striking example of the necessity of selecting varieties adapted to the particular conditions under which they are grown. It was replaced by the Cristalina hailing from Java, which had long been grown side by side with the Otaheite but never purposely planted because the juice was not so easy to manipulate, but which proved to be less narrow in its range of suitable conditions and retains its position to this day as the most widely distributed general purposes cane. It too is now being accused of deteriorating and in places is being replaced by forms with still wider adaptation or, as we say, greater resistance, and so the history repeats itself, the soils of the sugar world gradually but surely becoming worse instead of better through the extension of the industry to lands less suited to cane growing and the wearing out of the old time fertile soils. Surely this is an argument for the intensive cultivation which we have of late repeatedly upheld as the crying need of the hour in the present crisis.

The possibility of improving existing varieties through the selection of bud variations. Although it might appear from the previous section that Earle is of opinion that sugarcane varieties propagated vegetatively are immutable, he emphatically states that this is by no means the case. "Change is the universal law of living things............ No two buds, even of the same shoot, will produce absolutely identical plants." Sporting, a pronounced form of bud variation, is well known in the sugarcane, as well as in other plants, and this phenomenon is specially common in the tropics. Among the well known colour sports the author points out that at least two ribbon canes have thus arisen from the Otaheite itself. He further draws attention to the idea often urged by writers on the subject that other bud varieties probably occur which are only not known because of their less obvious character, and develops two lines in which improvement has been sought by what is practically bud variation, increased richness in the juice and greater vigour and resistance to specific diseases. The former had a great vogue at one time and he singles out Kobus' Java studies as specially worthy of mention. This worker however differed in his method from the rest in that he depended on mass selection, taking the heaviest canes in the field which he also found to be the richest in juice. But richness of juice is influenced by too many local factors, and nothing appears to have come of all this work, although Kobus claimed that he met with considerable success. The author considers that the problem is by no means proved to be insoluble, though difficult, and that it is worthy of further careful and continued effort.

Selection for greater vigour and resistance is much easier, and is to be prosecuted among those few flourishing clumps with which everyone is acquainted in heavily diseased fields. Earle refers to Java work in attacking the *sereh* problem and states that this is the only published instance, but similar work was done at the Samalkota Sugar Station in India, where independently the same method was applied with regard to red rot,[1] and a diligent

[1] Barber, C. A. *Scientific Report of the Samalkota Agricultural Station*, 1905-6, pp. 31–33. Dept. of Agri., Madras, 1907.

search would doubtless reveal many other cases. The results have been disappointing, and the author details his various attempts in Cuba and Porto Rico, one and all of which were frustrated by circumstances over which he had no control, and he concludes that this attractive field still remains open for future investigators. A great number of such sports have been marked down at different times as producing new varieties of promise, and at the present moment an ambitious scheme is actually being carried out, as we noted last month, in Hawaii where Shammel (whose Citrus work Earle mentions) is leading a campaign for increasing the production of sugar per acre in those islands.

The flowering of the sugarcane. This well known phenomenon was studied by some of the older writers who were even led to make use of it in their attempts at classification. Earle points out that this has proved of little practical value in that many kinds will flower in some years and situations and not in others, and states that the reasons for flowering are little understood. By observing that the canes flowered in Cuba in November and December, dry months, it was held by some that moisture was the determining factor, till it was noted that in Porto Rico the canes flowered in the same months although these were wet. He rightly states that age is a determining factor, but has not followed recent work in India on the subject where considerable progress has been made. Further, it has there been demonstrated that, given the necessary conditions, some classes of Indian canes flower freely, while, under no known conditions, have others been induced to do so, and all stages have been noted in the groups of canes between these two extremes. The differences between the tropical canes are less striking, but there can be no doubt that the flowering of the cane is a botanical character, which on occasion may prove very useful for the purposes of classification. Earle also approaches the question of the influence of arrowing on the richness of the juice and adduces additional evidence that the common belief in his islands that the juice is poorer after flowering is incorrect, by a simple analytical experiment. Nineteen pairs of canes of the same age and plots were analysed, and the table of results

is useful as so few have been published. The following are the average results of the experiment:—

	Extraction	Brix	Sucrose	Reducing sugars	Purity	Fibre
Arrowed	66·11	18·05	15·05	0·692	88·19	12·63
Non-arrowed ..	68·63	17·05	14·78	0·955	86·15	12·68

The author traces the common belief referred to to the fact that arrowing frequently takes place some time before harvest when, in the event of rain moistening the soil, shooting takes place with deterioration of the sugar content in the arrowed canes.

The ripening of the cane. Richness of juice depends more on maturity than on the variety grown, for a poor cane when ripe will have more sugar in it than a rich one not yet mature, a further cogent argument against the mixing of different varieties in the same field. After a cane has reached its optimum deterioration takes place, but at a very different rate in different kinds and under different external conditions. Thus Otaheite " goes to pieces " at a great pace while Cristalina is much more stable. The factors mentioned by the author as of influence in the ripening of the cane are as follows. *Soil moisture :* the juice attains its highest sucrose content when growth ceases, and this cannot occur when the soil is still wet. Thus the richest juice is invariably met with in countries where there is a markedly dry season. *Temperature :* cold assists ripening while heat retards it because of the stimulus to growth. The *character of the soil* has marked influence, the canes ripening more quickly on porous, well-drained land and in hill tracts than on low-lying retentive soils. *Fertilizers,* as is well known, may be used with great effect and similarly the *chemical composition of the soil* is of importance. Thus in new land, such as that of virgin forest, the first crops usually yield canes with low sucrose and the optimum is frequently not reached till the third or fourth harvest. Hence it is advisable to plant such varieties on it as Yellow Caledonia, B 3412 and Cavengerie, which give large tonnages of canes with poor juice, or to put B 208 in poor, worn-out lands. *Cultivation methods* are of influence in certain cases, as instanced by the trashing of canes in some localities

although this has not been found of advantage in Porto Rico. Tillage, while inducing growth, ceases when the canes close in and has therefore little permanent effect on the maturing of the crop.

Ripening is often indicated by a definite change in colour, green tending to become yellow and red or purple becoming duller, brownish or even olive green. The leaves become paler and less erect, and arrowing, while not of necessity occurring when the cane is ripe for harvest, is an additional indication that maturity is approaching. The *colono* system tends to crushing the canes when unripe, and the only sure method is to call in the aid of the chemist with rough preliminary tests of the composition of the juice. The importance of reaping the canes as near as possible to full maturity may be judged from the fact that in a 40-ton crop an increase of one per cent. of sucrose in the juice will mean 600 lb. of sugar obtained. There is a good deal more to be said on this subject, and the author might have added a note on the fact that in each clump it has been demonstrated that at no time are all the canes ripe together because of their differing age and order of branching,[1] which suggests that the correct point at which harvest should take place becomes still more a matter for experienced expert judgment.

Deterioration of the cane. This important subject is briefly treated. It depends primarily on the weather, frost and wet being especially effective, but also on the pests and diseases prevailing and markedly on the variety grown. Earle considers it remarkable that so few cases have been recorded of systematic preliminary analyses throughout the period of growth and refers only to a paper by Colon on Yellow Caledonia in Porto Rico. It is certain that a very great number of other references might be added by diligent search, and we merely note here the numerous cases dotted over Indian publications and the recent analyses month by month given in the latest Report of the Queensland Sugar Bureau. It is particularly important that the matter should be brought to the notice of the larger islands in the West Indies,

[1] Barber. C. A. "Studies in Indian Sugarcanes. No. 4. Tillering or Underground Branching." *Mem. Dept. Agri. India, Bot. Ser.* X, 2, July 1919, pp. 91–95.

for it is mentioned that in Cuba and Porto Rico a week is often allowed to elapse between cutting and milling, whereas the author lays it down that, while they can be safely allowed to lie over for two days, a further delay causes rapid change and loss of sugar. Burnt canes, on the other hand, whether intentional or accidental, must always be treated at the earliest possible moment.

METHODS OF MAIZE BREEDING FOR INCREASE OF YIELD.*

BY

H. WENHOLZ, B.Sc. (Agr.),

Inspector of Agriculture, New South Wales.

PROBABLY over 90 per cent. of the maize-growers in Australia select their seed maize in the barn at husking time, with little or no accurate knowledge of any definite relation of type of ear to yielding capacity. A comparatively small number of progressive growers select their seed in the field before or at harvesting time, and thereby effect some improvement in yield if they do it with care, and very few farmers indeed work on a reliable system of breeding by which yields can be definitely increased.

Much work has been done in America to show that there is little or no correlation between type of ear and yield, but these results have lately been questioned on account of the known suitability of certain types of maize to regions differing markedly in climatic conditions. In New South Wales a vast amount of evidence is being collected to determine what ear characters, if any, are correlated with yield for particular varieties which have become well established in different districts on account of their high yielding capabilities. The work of some experienced growers in selecting to a certain type over a long period of years, and in evolving thereby a fairly well fixed type which outyields other varieties of different type on their own farms, suggests that there is some kind of broad correlation between type and yield for a particular locality, or for a definite set of local conditions. The fact that many of these long continued selections have resulted also in repeated prize winnings at local agricultural shows suggests that there is some

* Reprinted from the *Agri. Gazette of New South Wales*, XXXII. 9.

relation between show points and yield in well established types in a locality.

In view of the repeated proof of lack of vigour and diminution in yield resulting from self-fertilization or close fertilization in maize, it would seem that distinctive varieties, like Boone County White and Reid's Yellow Dent particularly, which are American varieties of high uniformity and with good show points, are of too homozygous condition to be high yielding, but this is not the case.

In spite of the vigour derived from coupling heterozygous characters, such as would be possessed by different types as generally accepted, it appears then as if there is some maintenance or improvement in yielding capacity by the long continued selection of a certain type of maize for certain local conditions. If this is correct, the only objection to improving a variety of maize in yielding capacity by this means of simple selection is the long time necessary to get this well-established type.

To begin with a variety of maize consisting of a number of somewhat different types is to take many years to evolve a well fixed type, and to begin with a fairly well fixed type is to risk the unsuitability of the type to local conditions.

With a uniform strain or variety of maize which yields well in a district, selection of ears of the true variety type will probably do all that is necessary in at least maintaining or perhaps slightly increasing its yielding capacity. In such circumstances the ear-row system of breeding a variety of maize does not offer much hope of effecting any marked increase in yield. This is explained by the fact that where great uniformity exists it does not make for very great differences in the yields of individual ears (such as are obtained in a variety of maize which contains many types), and therefore no easy elimination of poor yielding ears can take place.

At the present time, however, very few varieties of maize in Australia are in such a state that they do not show marked differences in type of ears, which differ in yielding capacity when submitted to the ear-row test. Uniformity within the variety has been brought to a high standard by American breeders in some varieties, and the ear-row test in such cases is being found to be

of less value in increasing the yield of a variety of maize, and other methods are now being sought.

Before passing on to a brief description of these methods, there is something to be said in favour of field selection of seed, which has been shown to be a very profitable practice. There is little doubt about the advantage of selecting seed maize in the field over picking the seed ears in the barn, but the method which is considered to affect the yield more than any other is the application of the old principle of the "survival of the fittest"—in other words, the selection of ears from those stalks which grew in a full "hill," and which were surrounded by a full stand (growing under competition), the ears being up to or above standard weight and size. This is the ideal to aim at in the field selection of seed maize. Increases of from 5 to 7 bushels per acre have been made in New South Wales from field-selected seed over barn-selected seed.

For the foundation of any seed maize plot, then, the field-selected ears are most desirable, and this practice could be more largely undertaken by maize growers with profit.

As stated before, in many cases (especially where varieties have been subjected to selection for uniformity of type for many years), the efficacy of the ear-row test for improving the yield is now being questioned in America.

A brief description of the ear-row method of breeding maize will not be out of place here. A number of ears are selected and rows of equal length about 2 or 3 chains long are planted from each ear at the same rate of sowing. As it takes only a small portion of each ear to plant a row, the remnant ears are carefully kept till the following year, when the residues of the highest yielding ears, as determined by this test, are sown in a separate plot (breeding plot). This lays the foundation for an improved yielding strain of seed of the variety.

The chief objections which have lately been raised to the ear-row test in America are as follows :—

1. The male parentage is not regulated. Even the best selected ears have some mediocre sire or male breeding.

2. Too close breeding (resulting in loss of vigour) is brought about in the breeding plot and thereafter by only four or five of the best "remnant ears" being used as the foundation stock of the improved strain.
3. Insufficient increases in yield (it is stated) have been recorded on comparing the improved strain with the original strain to which ordinary selection alone has been applied.

The new methods of maize-breeding which are now being developed in America are based on the following points :—Self-fertilization, if carried on for some time, causes loss of vigour and diminution in size to a certain stage but no further. This stage is reached as soon as the selected individuals are either pure dominants or pure recessives, *i.e.*, homozygous for their many characters. All self-fertilized lines, therefore, become more uniform, but some lines do not lose vigour owing to consanguinity, as quickly or as much as others. In the recombination of such inbred strains increased vigour is at once restored, and a high yielding and uniform strain of maize is evolved which is said to be far superior to the original variety.

The advantages of this new system, which is referred to as "selection in self-fertilized lines," are apparently :—

1. Individuals with defective germ plasm suffer total extinction when self-fertilized for some time, though they may produce fair ears when bolstered up with cross-fertilization. This is a valuable elimination of the unfit which it seems impossible to effect in any other way.

2. The greater uniformity of inbred strains and their combinations—when a line becomes homozygous for any character it always remains so.

3. Once the pure strains are obtained and the particular recombination which gives the best yield is established, the same result can be produced each time the cross is made.

The possible disadvantages of this system are :—

1. In any self-fertilization, the amount of grain produced by a given maize plant is not visible until some time after fertilization is

effected. It may be possible to overcome this by establishing correlations between the field characters of the plant and the size or weight of the ear produced. This has not yet been done, and at present no likely correlation seems to exist.

2. Six to ten years' self-fertilization is required to bring a line to any homozygous and stable condition.

3. The methods involve considerable tedious work which an ordinary farmer would not have the time or the patience to undertake. Its use would therefore be restricted largely to experiment farms, where practically only one variety can be grown.

4. The skill of the operator or breeder plays a large part in the results obtained.

5. A large amount of material must be used ; at least 100 ears are desirable to start self-fertilized lines. As the grain production cannot be judged until after fertilization, it is necessary to self-pollinate four or five ears in each line, three of which should be grown, making at least 300 lines.

6. The selection of the poorest plants to be self-fertilized may mean the encouragement of defective or weak germ plasm, while the selection of the best plants tends to perpetuate plants in a heterozygous condition, which are usually the most vigorous.

7. The method of self-fertilization in maize by the use of bags on the silks and tassels does not sufficiently safeguard the introduction of foreign pollen in the field during the act of uncovering the silks.

8. There is no definite correlation between the producing capacity of inbred strains and the progeny of the crosses produced from them. All possible combinations of the inbred strains have to be tried and tested. If twenty pure lines are produced, at least 380 combinations have to be kept isolated and tested for yield, as even reciprocal crosses do not always give the same result.

9. First generation hybrid seed from two inbred strains is at a serious disadvantage on account of its small size.

10. Double crossing (*i.e.*, the combination of two first generation cross-breds) to overcome the latter disadvantage adds another year or two to the time taken to make and test all the

combinations, and means probably twelve to fifteen years at least to produce an improved strain of maize.

11. If the improved strain of maize is allowed to be grown for a few years, the vigour is lost, due to inbreeding or close breeding, and the yielding capacity becomes no better, perhaps worse, than that of the original variety. This possibility is likely with many farmers among whom the improved strain of maize would be distributed.

12. If the area devoted to the raising of pure line is one or two acres, as seems at least necessary, substantial loss takes place for many years on a small farm, owing to the poor yields obtained from this area.

13. No definite figures have yet been shown comparing the strain obtained by the new system of breeding with the original variety, or with the variety improved by a good system of ear-row testing.

The objections previously raised to the ear-row test as a method of obtaining increased yields of maize may be expected to disappear under certain conditions. As long as substantial variations occur in the yielding capacities of different ears within the variety of maize, it is contended by the writer that higher yielding strain of maize can be produced by this system.

The details of the ear-row method which is being continued in New South Wales (despite the introduction of these latest systems in America) have been altered slightly since its commencement, and the following description of the methods now being employed by the writer is given :—

Each year thirty-six ears, field-selected from the previous year's ear-row test, are submitted to the same test in rows about 3 chains long. These ears are the best that can be obtained (on appearance and weight), observing the precaution that no ear is selected except from a three stalk hill and surrounded by a good stand. In this way each selected ear in the ear-row test has apparently some inheritance of yielding capacity behind it, at least on the dam or mother side. Occasionally an ear of exceptionally good appearance from another breeder of the same variety, or

from a field area, is included in this plot which occupies about an acre in area. Until lately every fifth row was sown with bulk seed selected from the "breeding plot," but now this check row is sown alternately with an ear-row throughout the plot. Now the breeding plot, as before mentioned, is a small plot consisting of the best four or five remnant ears of the previous ear-row test. Of these, the progeny of the two highest yielding ears are detasselled and allowed to be cross-fertilized by the progeny of the next two or three highest yielding ears. From the detasselled rows in this breeding plot sufficient seed is usually selected to sow the check rows for the ear-row test next season, and to sow a special multiplying plot of a few acres. This multiplying plot is the plot from which the seed is selected to sow the whole farm area the following year.

As the ear-row test, the breeding plot, and the multiplication plot are continued each year, it will be seen that new and improved seed is produced each year in the breeding plot, and that each year also a new "strain" of seed is produced for the farm area. This method overcomes the objection that the breeding is somewhat close, and loss of vigour is likely to result after a few years from consanguinity, for fresh seed is produced for the farm each year.

Now it is readily allowed that consanguinity is not a danger in itself, provided the individuals mated are of robust constitution.

There may be a tendency to close breeding in the ear-row test on account of selection for uniform type which is more likely to contain homozygous characters, but this is to some extent obviated by the occasional introduction of good ears of the same variety from outside sources, and by the insuring of robustness or ability to yield from the method of field-selection practised.

Again, any ears in the ear-row test after the second year have to be very good to be able to beat the check rows in yield, which are sown with the best seed from the breeding plot, which in turn, as stated before, is sown with the élite remnant ears of the previous year's ear-row test. But some individual ears still are able to do this, and they are then eagerly made the breeding plot of the following season.

That stud seed from the detasselled rows of the breeding plot is superior to ordinary selected seed of the same variety is proved by the following results which have been obtained in New South Wales to date :—

Localit	Variety	Season	Yield per acre		
			Stud seed	Ordinary selected seed	Per cent. increase in favour of stud seed
			Bushels	Bushels	Per cent.
Hawkesbury Agricultural College ..	Red Hogan ..	1916–17	78·26	67·33	16·1
Grafton ..	Leaming ..	1916–17	35·17	24·50	46·5
Yarramalong ..	Improved Yellow Dent	1917–18	39·42	34·00	16·9
Kangaroo Valley ..	,, ,, ,,	1917–18	76·34	67·33	13·3
Paterson ..	,, ,, ,,	1917–18	104·28	87·00	20·1
Comboyne ..	Leaming	1918–19	60·90	51·31	16·7
Charity Creek ..	Improved Yellow Dent	1918–19	78·40	72·00	8·4
Leeton ..	Funk's ,, ,,	1918–19	20·44	17·32	18·3
	Average ..	..	61·40	52·38	19·5

That some ears in the ear-row test can still beat this stud seed in yield, and are then used as residues for the breeding plot the following year, shows that the maize-breeding work in New South Wales has been conducted on safe and sure lines up to the present. What the future will reveal is not apparent, but the ear-row test cannot be given up lightly in favour of something different until it is proved that it is not obtaining results.

It must be stated that, in the first place, the ear-row test has only been in operation on a variety of maize at the most for six years here ; but the present status (with the results achieved) overcomes objections to the ear-row test as a means of improving the yields of a variety of maize which are being raised of late years in America.

There is, perhaps, this difference, that the varieties of maize, in America, having been subjected to selection and ear-row-breeding,

are much more uniform than our varieties in New South Wales and that the great differences we get in our ear-row test between the yields of the different ears are not in evidence there.

This may be so, but the details of the method for ear-row testing, which have been described here, are not known to have been practised in America and, while the varieties of maize which have been subjected to this system still out-yield nearly all other varieties which are pitted against them, and are rapidly becoming the most popular varieties in New South Wales and in other States, it is felt that the continuance of the system of breeding outlined is justified.

A PROGRAMME OF COTTON RESEARCH.*

BY

RUSSELL T. FISHER,

Assistant Secretary in charge of Research, National Association of Cotton Manufacturers, Boston.

In the United States, research work on cotton has been going on for some time, but because of the lack of publicity given to the work of the laboratories it is rather difficult to estimate how much, and what, has been accomplished. Now that this Association has decided to develop a research department, it is thought that arrangements can be made to give much of this information wider publicity either through the monthly bulletin or by issuing pamphlets from time to time.

A research department must of necessity have in mind a rather definite object and the following general outline of research, under which practically all of the problems arising in connection with the cotton industry could be grouped, has been suggested to the Association not as a final, but as a tentative, programme until the work has progressed far enough to ascertain what modifications are needed.

(1) Raw material.
(2) Methods of manufacture.
(3) Standards of quality.
(4) Maintenance of quality.

1. *Raw material.*

The United States Department of Agriculture with the aid of the Agricultural Departments of the cotton-growing States and

* Extract from Paper read at the Annual Meeting of the National Association of Cotton Manufacturers, Boston. Reprinted from the *Textile World*, LXI, 18.

some of the cotton growers have been carrying on extensive investigations on the problems arising in connection with the cultivation of cotton with the ultimate aim of creating suitable varieties for the spinners' needs. Their work has been complicated by the almost continual growth and spread of destructive pests. Experiments in the last year have shown that the most destructive of these pests, the boll weevil, can be controlled if not exterminated.

Some of the results for which they hope are an increased and uniformly distributed spirality, greater uniformity of fibre length in the individual bale and a fibre that will not be brittle.

Valuable as their work has been in the past, their work in the future can be made of greater value by a closer co-operation with the manufacturers who can be of distinct aid to them by determining what properties are necessary and desirable in a fibre. Each mill may already know what properties in a fibre are most needed for the economical production of their fabrics but, until some agency such as this Association secures this information and by working with the Agricultural Departments shows what is needed, the full benefits of the resources of these departments cannot be realized.

The Agricultural Departments do not, however, cover the entire subject and many additional problems suggest themselves, a few of which are :—

Mechanical picking of the cotton crop. Many devices have been patented for picking the cotton from the boll by mechanical means but until recently the machines have not proved satisfactory. The past season a new cotton picker was tried out on a small scale, and was reported to have been successful not only in picking quantity but also in picking cotton more uniform in maturity and with less leaf dirt.

Utilization of tinged and stained cottons. Tinged and stained cottons have been used in the past for many fabrics where the resulting slight cast was not objectionable. When used in bleached or dyed fabrics it has often resulted in streaks and uneven shades. *Bulletin* 990 *of the Department of Agriculture* gives the results of a series of experiments in which the yellow tinged and stained

cottons were successfully bleached and dyed and the blue stains successfully dyed. The experiments are to be continued in attempts to find a successful bleach for the blue stained cotton.

2. *Methods of manufacture.*

Probably nowhere in a research programme can the mills be of more assistance than in improving methods of manufacture. If the results of all the experiments that have been carried out in the mills could be obtained many apparent problems would be solved already. There has been in the past a decided opposition to this exchanging of information, but most manufacturers now realize that there is very little in their mill practice that is secret and believe that anything which aids the whole industry will also help them individually.

The mills to-day can take a bale of cotton and work out a complete organization which will give a certain result. Why certain things are done or what happens to the cotton in the several machines is not always clear.

* * * * *

One of the problems of vital interest to every manufacturer is the study of the effect of humidity on cotton. It is well known that moisture is essential for the carrying out of some of the processes ; what moisture content will give the best results on the different types of cotton and what moisture content will give the best results on the same type of cotton while passing through the machines has not been established. A questionnaire sent out to three concerns manufacturing air moistening machinery, asking their opinion in regard to the relative humidity desirable in the different rooms in the cotton mill, resulted in three replies, each recommending different humidities for the majority of the rooms. The reply was, in one instance at least, based on observations in several mills and not on the result of research.

The importance of knowing what the humidity should be and then of keeping that humidity is well illustrated by one mill which intends to maintain the relative humidity in the card room above

50 per cent. Occasionally the relative humidity is unintentionally allowed to drop below 50 per cent. As soon as the cotton gets to the spinning frame serious trouble from broken ends develops and continues until the moisture content of the cotton in the card room is brought to the proper point.

A few of the other problems which have been suggested and which would come under methods of manufacture are :—

The effect of mixing different kinds of cotton for special yarns.

A study of single carding and double roving versus double carding and single roving.

The strength of cotton yarn as influenced by staple and twist.

* * * * *

4. *Maintenance of quality.*

The means of determining whether or not the quality of a textile material has been maintained are somewhat limited at the present time. Many of the important properties can only be partially or approximately measured. New test methods are being developed and old methods are improved upon, but there is still a need for extensive research work.

Another great need is the standardization of test methods. At the present time, the results of tests have little value unless accompanied by a detailed description of the method used, and even then the test methods may vary so that the results are not comprehensive.

The textile committee of the American Society for Testing Materials and the Bureau of Standards have developed methods of test for a limited number of fabrics, but lack of publicity has prevented their methods from becoming widely known or used.

* * * * *

As the Association is not prepared to undertake such an extensive work a few specific problems have been selected from the general programme and it has been recommended that as many of these be worked out as is possible at the present.

TENTATIVE PROGRAMME.

1. Study of fibre length.

(*a*) The determining of the average length of the staple in a lot of cotton, also the proportions of fibre above and below the average.

(*b*) Effect of the different machines on the length of the fibre.

The applications of the study of fibre length are self-evident, as it is known that the cotton fibres in one bale may vary widely in length and that different classes will vary in their estimate of length.

Occasionally the fibres in the yarn are found to average shorter than the average determined from the bale, indicating that the fibre has been cut or broken in the manufacturing process. Until recently, methods of accurately measuring fibre length have been lacking, but now several machines are obtainable which should enable the investigator to work back and locate the machine causing the trouble.

2. A study of the effect on the stretch of the different types of size and methods of application.

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3. Establishing of a comparative scale of colour fastness.

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4. Development of test methods and determination of the physical properties of yarns and fabrics.

The need for the development of test methods and determination of the physical properties of yarns and fabrics was shown under maintenance of quality.

5. The collecting of existing data.

There are several commercial laboratories in addition to the textile schools and mill laboratories which are doing work, the result of which if collected and classified would undoubtedly be of interest and value. Several of these laboratories have already signified their willingness to co-operate and an endeavour will be made to make the Association a clearing house for such information.

In addition, the research department offers to the Association members an opportunity to have tests made which will be entirely unbiased and free from the personal element which sometimes unconsciously influences the mill laboratory man when the desired result is known. This part of the work is already in progress and several samples have been tested and analysed for members of the Association.

ANNUAL REPORT OF THE BRITISH COTTON GROWING ASSOCIATION FOR THE YEAR 1921.

THE summary of the year's working shows that the Association handled a record amount of cotton from new sources, *viz.*, 63,966 bales as compared to 23,513 in the previous year and 40,730 in 1916. The increased production of cotton in new fields in the British Empire reached the record of 165,100 bales in 1921 as compared to 105,800 in 1920 and 78,800 in 1916. Of these new fields, the Uganda Protectorate with 81,300 bales is the most important, followed by Nigeria with 31,500 bales and the Sudan with 27,700 bales, whilst the West Indian crop, steady since 1916 at 4,500–5,500 bales, is of peculiar importance on account of the exceptional value of the Sea Island cotton produced.

The guarantee of a minimum price for seed cotton (*kapas*) of $3\frac{1}{2}$ *d.* per lb. for indigenous cotton and $4\frac{1}{2}$ *d.* per lb. for exotic varieties to the native growers in Nigeria at one time looked like involving the Association in a loss of £300,000 ; but an improvement of prices and careful management of hedges enabled the Association to offset this loss and show a small profit.

A brief reference is made to the starting of work in the estate at Khanewal, Punjab [managed by the subsidiary company British Cotton Growing Association (India)]. This estate has an area of 7,500 acres situated on the Lower Bari Doab Canal and the intention is to grow cotton on this area under a scientific system of rotation of crops and to demonstrate the best method of cultivating and handling the cotton crop.

WEST INDIES.

High costs of production with a lessened demand for the finest goods have made conditions here difficult. The efforts to control the pink boll-worm appear to have been successful.

Nigeria (Southern Provinces).

Not only is cotton growing steadily expanding but the indigenous cottons are being steadily replaced by stapled American varieties. The Agricultural Department has now dropped "Georgia" cottons and is concentrating on Allen's Long Staple. In the Northern Provinces also expansion of long stapled cotton growing since 1916 has been rapid, having risen from 121 to 6,871 bales with prospects of a further large increase in the current year. To this extension the Association's guarantee of a minimum price contributed largely, and although with the heavy fall in American cotton prices the guaranteed minimum had to be greatly reduced at the end of the agreement, expansion continues.

Kenya.

Production in this colony aggregated some 300 bales only, prospects are not encouraging, though with the fall in the prices of flax, coffee, maize, rubber, etc., cotton production may increase in those districts which are suited to it.

Uganda.

Notwithstanding the low prices ruling during the period whilst the crop was being marketed, the 1920-21 cotton crop in Uganda was a record one. The number of bales exported during 1921 exceeded 81,300 as compared with 52,000 bales in 1920. This result has been achieved under the most adverse conditions, as many ginners and traders were not in a position to buy cotton. The Association purchased nearly 12,000 bales, which was as much as their local staff could possibly deal with, and a letter has been received from the Secretary of State for the Colonies expressing his full appreciation of the stimulus which the Association have given to the disposal of the 1921 Uganda crop by their specially large purchases. Acting on the representations of the Association, the Government stepped in and purchased the crop in a number of districts where there were no other buyers.

The export duty of £1 per bale is still in force, and under present conditions it weighs heavily on the industry. An assurance

has been given that this tax will be reduced as soon as possible, the tax having been originally imposed at a time when values were abnormal. The premiums which have been charged by the Government for some years on new ginnery sites have now been abolished.

TANGANYIKA.

The crop for 1921 was estimated at 7,500 bales and definite efforts are now being made to foster cotton cultivation in suitable districts. At present the quality of the cotton is said to be distinctly inferior.

NYASALAND.

The Nyasaland cotton export tax of 2*d*. per lb. of lint cotton was abolished as from the 1st of April 1921, which will doubtless have a good effect in the revival of the cotton growing industry in the Protectorate.

The industry has suffered in the past owing to the non-stabilization of the price and the allowing of all and sundry to buy the crop. Various regulations have been introduced to overcome these difficulties, but so far without any satisfactory result. When the price of cotton on the Liverpool market is high, there is absurd competition to purchase the native crop, whilst when the price is low, speculators will not take the risk. Practically the whole of the 1921 native crop was purchased by the Association, based on the Liverpool values ruling at the time for such cotton, and on the whole the quality of this cotton has been rather better than in recent years.

At the request of the Director of Agriculture (Mr. E. J. Wortley) for a cotton expert, the Empire Cotton Growing Committee sent out Mr. H. C. Sampson, C.I.E., from June to August 1921. Mr. Sampson has had considerable experience in the growing of improved varieties of cotton in India, and the Governor of Nyasaland writes that Mr. Sampson's visit has created a most favourable impression, both with the Department of Agriculture and the planters, and his experience and knowledge of cotton has proved of great advantage to the Protectorate.

South Africa and Rhodesia.

The production of cotton in the Union of South Africa during 1921 was rather less than in the previous year, and was doubtless caused by the fall in values. About 2,000 bales of 400 lb. each were produced, and although the staple is rather short, the cotton has sold readily on the Liverpool market at fair prices. Out of the total crop, the equivalent of 653 bales of 400 lb. each have been shipped to the Association through the Cotton and Tobacco Exporting Co. of Pretoria, and 418 bales of 400 lb. each through the Rustenburg Boeren Kooperatieve Vereniging of Rustenburg, Transvaal. The cotton has been carefully graded and dealt with in a manner most praiseworthy to both these concerns.

In Rhodesia the agricultural authorities continue hopeful but not oversanguine as regards the future of cotton growing in the country, and a number of experiments are being carried out in various districts.

Sudan.

The cotton crops on the estates in the Gezira Plain, controlled by the Sudan Plantations Syndicate, Ltd., were less than the previous very favourable year, chiefly due to the exceptionally heavy rains which fell at the commencement of the cotton season.

At Tayiba 5,117 kantars* were produced from 1,700 feddans† as compared with 9,578 in the previous year.

Owing to the above reason and an unfortunate breakdown in the pumping station the yield at Barakat was only 6,704 kantars from 2,011 feddans as compared with 10,294 kantars in 1920.

The work at the Hag Abdulla Pumping Station has progressed rapidly, and 6,040 feddans have been planted with cotton : this new cotton station has been given the name of Hosh.

The area under cotton at Zeidab was 3,170 feddans, which produced 5,570 kantars as compared with a production of 7,700 kantars in the previous season.

With reference to the Gezira irrigation scheme, work on the construction of the dam at Makwar on the Blue Nile and the canal

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* 1 Kantar = 99·05 lb. † 1 Feddan = 1·04 acres.

system is being carried on by the Egyptian Ministry of Public Works, the necessary funds being provided by the Sudan Government.

Unfortunately construction is costing a great deal more money than the estimates provided for, owing to the general rise in the cost of labour and all materials due to the late war.

There has been some danger of delay in the carrying out of the works owing to the difficulties encountered by the Sudan in making the necessary financial arrangements to meet this increased cost of construction.

The Association, through their President, exerted every effort to avoid this calamity, and as a result the Treasury agreed to an arrangement enabling the work on the scheme to be continued for another season pending further examination of the revised estimates of cost.

An expert nominated by the Treasury was appointed by the Sudan Government to report on the cost and methods of the execution of the work.

It is understood that the report of this expert is entirely favourable to the scheme.

With the difficulties encountered in the carrying out of the Gezira irrigation scheme disposed of, it is hoped that something further will be done before long to open up and develop the cotton growing areas at Tokar and Kassala.

In the case of the former the Sudan Government during 1921 constructed a light railway line for the transport of the cotton from the Tokar market to the seacoast at Trinkitat.

Mesopotamia (Iraq).

Owing to the unsatisfactory political situation which still exists in this country, it has not yet been possible to adopt any progressive policy. During 1920 the aggregate quantity of improved seed which was sown amounted to 14,828 lb. This quantity would suffice for an area of about 400 acres, to which may be added 200 acres grown on Government farms. The estimated yield of white cotton was 350 bales of 400 lb. each, but, owing to considerable difficulties being experienced in securing the necessary supply of

water during the months of July and August, the ultimate crop is sure to be considerably reduced.

There has been a better demand for seed for planting for the 1921-22 crop, and, although progress will necessarily be slow, the prospects for the future are undoubtedly much brighter.

QUEENSLAND.

The development of cotton cultivation in Queensland during the year has been very satisfactory. In the last Annual Report it was mentioned that the Association had been approached by the Queensland Government authorities with reference to a scheme for establishing a number of ex-service men on the land. As a result the Council consented to guarantee for a period of five years a price of 1*s.* 6*d.* per lb. of lint delivered at Liverpool for clean cotton forwarded to them from Queensland. The cotton was to be produced from approved types of seed of longstapled cotton to be issued to growers by the Queensland Agricultural Department, and the guarantee was to date from 1st January 1920, the Association's loss throughout the whole period not to exceed £10,000. During the year 1,256 bales, weighing 314,662 lb., have been received, but the better quality has only a staple of 1⅛″, which places it under a totally different class from cotton of 1 3/16″ to 1¼″ staple. Although this cotton is quite good of its kind, it is doubtful whether the prices ruling over a number of years would be such as to make the industry a payable one for cultivators,* unless a better quality can be produced.

The latest reports are to the effect that 20,000 acres are already being cultivated with cotton in Queensland, which should result in a crop of at least 8,000 bales. The Queensland Government authorities are of the opinion that cotton growing offers the most adequate plan yet considered for dealing quickly with the problem of immigration.

CONCLUSION.

The period under review has been a very trying one for all sections of the cotton trade, but, notwithstanding the reduced

* The cost of production in Queensland is extremely high.

demand for cotton goods owing to the poverty of the world's markets, the necessity for the development of new cotton growing areas is more urgent than ever. The comparative failure of the American cotton crop would have proved a disaster in normal times, and there must be an ever increasing number of those engaged in the cotton trade who fully realize the seriousness of the developments of the past season in connection with the advance of the boll-weevil, which has gradually worked its way so that the whole State of South Carolina was covered, and North Carolina (the limit of the cotton belt) was affected to the extent this year that South Carolina was in 1920. It is only a comparatively few years ago that the boll-weevil crossed the Rio Grande from Mexico, and it has gradually swept northward until now the entire cotton growing area has become affected. In future the yield per acre will necessarily be lower throughout the States, in addition to which the cost of cultivating the crop will be enormously increased. There is also a tendency towards diversification of crops in the South, which is likely to be more marked in the future.

The increased cotton production within the Empire which has taken place during the year in Uganda, Nigeria and the Sudan, is very gratifying, and although temporary set-backs are inevitable, due to climatic and other causes, there can be no doubt but that the industry in these countries is now firmly established, and that as larger areas are opened up by transport facilities, the quantities of raw material available for Lancashire spinners and manufacturers will steadily increase.

APPROXIMATE ESTIMATE OF COTTON GROWN IN NEW FIELDS IN THE BRITISH EMPIRE.

(Bales of 400 lb.)

	1915		1916		1917		1918		1919		1920		1921	
Gold Coast ..	100		100		100		100		..		..		..	
Nigeria— Southern Provinces..	6,300		9,400		7,900		3,100		9,500		10,700		19,500	
Northern Provinces..	1,200		10,800		3,900		3,000		8,000		5,500		12,000	
WEST AFRICA		7,600		20,300		11,900		6,200		17,500		16,200		31,500
Uganda Protectorate	25,200		25,100		24,000		23,000		35,000		52,000		81,300	
Kenya Colony ..	300		200		200		200		100		100		500	
Tanganyika Territory	..		..		..		..		..		..		7,500	
Nyasaland and Rhodesia ..	9,000		8,500		6,500		5,000		2,200		3,000		4,600	
Union of South Africa	390		330		380		640		2,000		2,500		2,500	
EAST, CENTRAL AND SOUTH AFRICA		34,890		34,130		31,080		28,840		39,300		58,100		96,400
SUDAN		24,000		16,200		23,000		12,000		12,300		22,000		27,700
WEST INDIES ..		5,600		3,500		3,000		4,500		5,500		4,500		4,500
SUNDRIES		3,110		4,670		3,620		3,360		5,000		5,000		5,000
TOTAL ..		75,200		78,800		72,600		54,900		79,600		105,800		165,100
APPROXIMATE VALUE..		£1,123,200		£1,500,000		£2,700,000		£2,349,000		£5,593,000		£3,617,300		£3,929,000

Notes

RECORD MILK YIELD OF A CROSS-BRED COW.

Mr. Power, Manager of the Military Dairy at Lucknow, reports conclusion of the fifth lactation of Edna, the heaviest yielding cow of the herd, with 15,324 lb. milk in 360 days. She is being dried off now as within 2 months of her next calving.

Edna is sired by "Sea Lord," a Friesian imported from Australia in 1912. Her dam was a Hariana cow whose best yield was 2,248 lb. in 337 days.

Edna first calved in March 1917, and her lactations are as follows :—

lb.		Days
6,521 ..	..	.. 438
6,750 ..	..	.. 225
7,031 ..	..	.. 245
10,345 ..	..	.. 374
15,324 ..	..	.. 360

In the lactation now finished she gave in short periods of—

7 days ..	..	.. 623 lb.
30 days ..	..	2,388 lb.

[J. Matson.]

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POISONOUS PROPERTY OF *ACACIA TOMENTOSA*.

In April 1921, Mr. G. Taylor, Superintendent, Civil Veterinary Department, Bombay, sent a few pods of *Acacia tomentosa* with the report of the Veterinary Assistant of Godhra that the green pods

when eaten by cattle during periods of deficient fodder supply give rise to poisoning, the symptoms being drowsiness, salivation, etc.

This plant is found growing wild in the Dang Jungles, in the Panch-mahals and in the Shelapur District. It is a small tree with yellowish bark and tiny greenish white flowers. Its vernacular name as given by Cooke is *anjar*, but in the Panch-mahals the plant is known as *rengda* and the pods are named *aniar*. Two varieties known as *mitha* and *mena* were at first believed to be in existence, the latter being poisonous to cattle, causing even death. Later reports however go to show that all plants belong to the same variety but some bear bitter pods which cause poisoning while others have sweet ones.

A feeding experiment with two full-grown rabbits was started on 18th April, 1921, after they were kept without food for the previous 24 hours. On the first two days the animals were served with 10 pods, from the third to the seventh day with 40 pods and on the last day with 60 pods, all of which were consumed. On the 26th April, 10 pods previously soaked in water for 24 hours were given and they were all eaten in the course of the day. The next day the animals seemed a little pulled down and restless. On two days of the experiment *hariyali* grass 7 to 8 *tolas** in weight was also given. The two animals together consumed in the period of the experiment 280 pods without any ill effect. The pods without the seeds were reported by the Agricultural Chemist to contain 0·108 per cent. of hydrocyanic acid which is the poisonous principle involved. The seeds do not contain any such property.

A second trial was made in April 1922 from material received from the Veterinary Assistant, Godhra. This material had become mouldy on arrival, but pods having very little or no mould were sorted out, dried and then fed to two other rabbits. The animals were without food for 24 hours when the experiment started on 1st April, 1922. Five *tolas* of pods were given per day to each animal whose daily feed varied from 1½ to 3 *tolas*, the average

* 2½ tolas = 1 oz.

consumption being 2·28 *tolas*. The animals maintained their health throughout the trial which was closed on 11th April for want of feeding material. A sample of the pods was sent to the Agricultural Chemist for analysis, who reported that the material contained 0·045 per cent. of hydrocyanic acid.

It may be noted that in the first feeding trial the animals had been given grass for two days in addition to the pods. In the second experiment nothing else than the pods was given.

The trials suggest a certain immunity to hydrocyanic acid poisoning. The killing dose has yet to be ascertained but appears to be above that contained in the rations given to the rabbits. [G. B. PATWARDHAN.]

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AN IMPROVED METHOD OF WHEAT SOWING FOR CENTRAL INDIA.

WE take the following interesting facts from a paper on the subject read by Mr. K. R. Joshi, L.AG., Senior Agricultural Assistant, Department of Agriculture, Holkar State, at the Ninth Indian Science Congress, Madras, 1922.

In Central India, particularly in Malwa, where the proper sowing season for *rabi* crops extends over a very short period, sowing is usually done by means of a plough with the usual seeding attachment (*nai*). In addition to other disadvantages, the operation is necessarily slow, $1\frac{1}{2}$ to 2 acres a day being the maximum rate per plough. Trials extending over five seasons of varying rainfall with a 2-coultered drill, such as is used in the locality for *kharif* crops, with the object of expediting sowing, brought out some useful information regarding depth of sowing, spacing, etc. The maximum depth at which the seed could be sown with the drill was $3\frac{1}{2}''$ compared with the usual depth of $5\frac{1}{2}''$ with the plough and *nai*, but as there was no deficiency of moisture in the soil at this depth, the germination was better and earlier by 24 to 36 hours.

As regards spacing, the results of three years' experiments indicate that 18″ planting gives better results than the usual local practice of 15″ planting. The benefit is greater in case of shallow

sowing with the drill than in case of deep sowing with the *nai*. The drill showed to greater advantage with a 50 lb. seed per acre than when this was increased to 70 lb. per acre.

The draught exerted by the drill and the *nai* being about the same, it is reported that the main advantages of the drill over the *nai* are :—(1) It covers twice the area sown by the *nai* and thus takes half the time required by the latter. (2) An average saving of 11 lb. of seed per acre was effected on account of a wider and more economic spacing—the loss of seed increasing with the increase in the seeding depth and decreasing with the increase in the distance between the rows. (3) An increased yield of about 16 per cent. was obtained. The visible effects of the shallower sowing by the drill were a better growth, better tillering, shorter crowns and a more even crop. For the drill the seed-bed requires, however, to be deep and fine, and the sowing should be done when there is sufficient moisture at the seeding depth which requirements probably explain why the use of the *kharif* drill has not hitherto become general in the tract.

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MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA DURING THE SEASON 1921-22.

EIGHTEEN factories making sugar direct from cane worked in India during the season 1921-22. Nine of these are situated in Bihar and Orissa, six in the United Provinces, one in Assam and two in Madras. Enquiries were instituted by the Sugar Bureau to ascertain the output of these factories, and we are much indebted to the management of each factory for the promptness with which the statistics required under various heads were furnished.

The table below gives the total figures of cane crushed, sugar made and molasses obtained by the factories in (1) Bihar, (2) the United Provinces and (3) other provinces of India. The total production of sugar direct from cane by modern factories in India amounted during the season 1921-22 to 7,53,638 mds. or 27,634 tons as compared with 6,69,291 mds. or 24,541 tons in the previous season.

Total production of sugar by factories crushing cane for the seasons November to April 1921-22 *and* 1920-21.

	Cane crushed		Sugar made		Molasses obtained	
	1921–22	1920–21	1921–22	1920–21	1921–22	1920–21
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
Bihar and Orissa ..	75,95,221	65,77,083	5,24,677	4,65,100	2,98,383	2,61,620
United Provinces ..	21,27,737	25,47,871	1,46,910	1,56,777	92,713	1,19,231
Other provinces of India ..	10,36,678	6,06,461	82,051	47,414	44,371	23,861
Total for India ..	1,07,59,636	97,31,415	7,53,638	6,69,291	4,35,467	4,04,712

It will be seen that the major portion of sugar production in India is from North Bihar where, roughly speaking, cane from an area of over 30,000 acres was put through factories. Although the United Provinces have the largest percentage of the total area under cane in India, the production of refined sugar by modern methods in these provinces fell during the year by nearly 10,000 maunds.

A comparison of the statistics will show that factories were fortunate in getting more cane for milling (10,28,221 mds. additional) in the season 1921-22 than in the previous season, resulting in an increased output of sugar for the whole of India by 84,340 mds. A slight improvement is also noticeable in the efficiency of the factories as regards the recovery of sugar from the cane crushed and the consequent reduction in the production of molasses. If we take the all-India figures we find that on an average 14·28 mds. of cane were required this season to produce 1 maund of sugar as compared with the 14·54 mds. required in the previous season. Similarly, the percentage of molasses to sugar manufactured has fallen from 60·47 in 1920-21 to 57·78 in the season 1921-22.

It is hoped to collect and publish in due course figures regarding the production of sugar from *gur* or *rab* by modern refineries in the working season of 1922. [Kasanji D. Naik.]

NITROGENOUS FERTILIZERS FOR SUGARCANE.

Dr. J. Kuyper, Assistant Director of the Pasoeroean Sugar Experiment Station, publishes in *Mededeelingen van het Proefstation voor de Java-suikerindustrie*, Jaargang 1922, No. 3, an interesting paper on the relative value of several nitrogenous fertilizers for sugarcane cultivation in Java. It is necessary to mention that, under the supervision of the Sugar Experiment Station at Pasoeroean, field trials have been carried on for many years on a great number of sugar plantations about the relative value of nitrogenous fertilizers. Sulphate of ammonia, which is commonly used as a fertilizer in Java (the average amount applied is about 380 lb. per acre), was taken as the basis for comparison.

During the last ten years 162 comparisons were made between sulphate of ammonia and nitrate of soda. These two fertilizers proved to be of equal value but sulphate of ammonia is preferable, because it is less hygroscopic.

Nitrolim or cyanamide was not found to be so good as sulphate of ammonia. In about 100 field trials, the latter manure showed better results in 53 cases and only in 24 cases did the former give equal results to sulphate of ammonia.

Ammonsulfaatsalpeter, imported by the "Badische Anilin und Sodafabriken," proved to be too hygroscopic for the conditions in the tropical rainy season.

Ureum, also imported by the "Badische," was compared with sulphate of ammonia in 12 field trials, and gave similar results.

As the result of a more detailed study groundnut cake has been found to be not so good a fertilizer as sulphate of ammonia. This cake applied with sulphate of ammonia gives better results than when applied alone.

In all experiments the same weight of nitrogen was given in the different manures.

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VISUAL DEMONSTRATION OF THE EFFECT OF MOISTURE ON THE MANUFACTURE OF COTTON.

The first public demonstration of the use of the moving picture camera for research work in textile manufacturing was a notable

feature of the convention of the American Cotton Manufacturers' Association in Washington. The picture was a two-reel film, entitled " Thirsty Cotton, an Analysis of the Effect of Moisture on the Manufacture of Cotton," prepared for the Parks-Cramer Company, manufacturers of humidifying apparatus, Fitchburg, Mass., and Charlotte, N. C. by the Worcester (Mass.) Film Corporation, and shown in Room D of the Hotel Washington. The film was completed too late to be given a place on the regular convention programme, but was shown several times each day outside of convention session hours to appreciative audiences of manufacturers.

Not only did the pictures demonstrate in a conclusive manner the need of proper humidification in cotton manufacturing, but by the use of close-ups and the slow-speed projector they proved the correctness of certain theories and gave rise to doubts as to others ; these particular features of the film represented research work of a high order and gave an effective demonstration of the value of the moving-picture camera for more intensive research work on the fibre and manufacturing processes.

Some of the interesting disclosures.

For instance, the use of the ultra-speed camera and slow-speed projector applied to roving machinery enables one to perceive for the first time that dry, statically charged bunches of fibre actually leave the roving before entering the flier and jump over the twizzle to the roving which is entering the channel of the flier arm, resulting in a slack-twisted and uneven product.

Another picture indicates the absolute elimination of this serious fault without the slightest evidence of static electricity when operating with a properly humidified atmosphere.

Somewhat less dramatic than the series of pictures just mentioned, but even more significant, was that part of the film showing for the first time the cause of the peculiar behaviour of dry and moist fibres during breaking tests. The card sliver used for this series of pictures is shown slowly and steadily separating in the jaws of a testing machine, and so highly magnified that, as the sliver separates, the individual fibres are distinctly visible. Dry

fibres show very slight resistance to separation. When moist, however, the fibres behave almost as if they were alive. Each fibre seems to cling to its neighbour, and at the exact moment of parting there is a very pronounced recoil like that of a suddenly released spring, indicating how much more elastic the individual fibres have become as the result of their contained moisture.

Scarcely less interesting and significant were the double exposure picture showing the striking difference between yarn being spun with and without sufficient moisture; those showing the effect of static electricity in the carding process, and the contrasted conditions disclosed on the drawing frame. [*Textile World (U.S.A.)*, LXI, 22, June 1922.]

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COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

ORIGIN OF EGYPTIAN COTTON.

The cultivated Egyptian cottons can all be referred back to two species, *viz.*, *G. barbadense* and *G. punctatum*, which were crossed with other types. The pure strains are very seldom found. It is difficult to distinguish between the numerous types of cottons, an examination of the seed hairs being the best method of doing so. All forms represent hybrids which is also revealed by an examination of the seed. [*Bot. Centr.*, 1922, **143**, 243; from *Bull. Soc. Vaud Sc. Nat.*, 1921, **53**. A. E. BLANDENIER.]

WATER REQUIREMENTS OF PIMA COTTON.

This is a report of the results of an investigation of the behaviour of Pima cotton, when grown under different conditions of soil moisture and available plant food, in the Salt River Valley. As a result of these experiments it is believed that the behaviour of the plants will serve as a practical guide in judging the need of irrigation and that the determination of the moisture content of the soil will be unnecessary except in critical cases. Certain phenomena were

noted in regard to the water relations of the different sizes of plants produced under varied soil-moisture conditions, indicating a retardation of growth and fruiting activities during the late development of the large plants. A discussion is included of the period of maturation for Pima bolls, data for the shedding of immature bolls, distribution and depth of penetration of the roots of Pima cotton and other phases of the irrigation problem. (*U. S. Dept. Agri. Bull.* No. 1018. C. J. KING.]

PLANT TRANSPIRATION.

The authors have studied the laws governing evaporation from free water surfaces and through perforated septa under varying conditions, and especially in moving air, using a special apparatus by which temperature, humidity and wind velocity can be maintained constant and can be varied. They worked with absolutely dry air and ascertained the quantity of water taken up per hour. From their results they conclude that in nature, where generally greater wind velocities prevail, it is not the forms of leaves, plants and corollas which determine the amount of transpiration but the size of the total surface. The paper concludes with a discussion of Freemann's transpiration experiments. [*Bot. Centr.*, 1922, **143**, 233-234 ; from *Jahrb. f. wiss. Bot.*, 1921, **60**, 459-498. H. SIERP and K. L. NOACK.]

OSMOSIS OF PLANT CELL.

The results of a general study of osmotic equilibrium between the cell and the surrounding medium are reported. The experiments were carried out on marine algæ and it is stated that the classic doctrine which likens the plant cell to an osmometer does not account for all the facts observed. [*Compt. rend.*, 1922, **174**, 1490-1492. L. LAPICQUE.]

TORSION CONSTANT OF COTTON HAIR.

The author assumes that a measurement of the force required to break a single fibre by twisting it is of practical value. He proposes to determine this by fixing the fibre in a clamp which can be rotated, and counting the necessary revolutions, the fibre being

held taut by a weight which cannot revolve and which is just sufficient to prevent it from winding up. The Schopper twist apparatus can be used. In a mathematical treatment of the subject it is shown that torsion × diameter is a constant, and this was confirmed in the case of sisal and hemp by actually measuring the cross section of the broken fibre. This proposition is further elaborated into the formula, torsion $/\sqrt{N}$ = a constant, where N is the "number" of the fibre, *i.e.*, the length (in metres) per grm. In the case of the cotton hair, the length tested was 1 cm. and the load was 0·57 grm. The mean number (N) was 558·3 ; the mean number of turns before break 269·3 ; the mean of the numbers below the average 219·9, and the mean of the higher numbers 337·9. The "torsion constant" is therefore $269{\cdot}3/\sqrt{558{\cdot}3} = 35$ for a 1 cm. length or 350 per metre. Cotton has a higher value than other fibres ; thus, silk, 248 ; sisal, 221 ; manilla, 218 ; Lincoln wool, 214 ; Dutch hemp, 141 ; blue flax, 130 ; artificial silk, 125 ; jute 64. [*De Textielindustrie*, 1922, **3**, 253-258. J. BECKERING VINCKERS.]

TESTING OF COTTON YARN.

The application of statistical methods in yarn testing is discussed. The author describes briefly the method of obtaining the probable error and its significance. Further, he deduces that for accurate work in yarn testing 200 tests are necessary in all cases in order to obtain a mean of reasonable reliability, whether the yarn is an uniform one, or obviously irregular. [*Text. Rec.*, 1922, **39**, 41-42. E. A. FISHER.]

MATHEMATICAL CONTROL OF FIELD PLOTS.

In connection with the theory of probabilities applied to field experiments, the contents of the following five papers are summarized :—(1) T. Roemer—Technique of Field Experiments ; (2) H. Vater—Calculation of the Compensation in Experiments on Soil Cultivation ; (3) W. Schneidevind, D. Meyer, and F. Munter—Experiments on the Size of the Plots ; (4) H. Vagler—Relation between the Size of the Plots and the Error in the Individual Observation in Field Experiments ; (5) H. von Rodewald—Mitscherlich's

Compensation Calculation for the, elimination of Soil Differences in Field Experiments. [*Bull. Agri. Intelligence*, 1921, **12**, 250–253.]

DESCRIPTION OF TEXTILE FIBRE PLANT.

A description is given of a new fibre-yielding plant which has been obtained as the result of repeated selection from a native rubber plant. The new plant furnishes three products simultaneously: (1) the bast fibre, (2) a seed hair similar to kapok, (3) rubber. The plant is a perennial and can be very cheaply cultivated. It requires a tropical or sub-tropical climate and must have a sufficient quantity of water, otherwise no special soil conditions are necessary. The bast can be easily and rapidly obtained by hand labour, or by simple machinery from fresh-cut, woody shoots. The production of the raw material is therefore very cheap, as is the preparation of the fibre. The single fibres can be separated by hand so that they are as fine and as free from impurity as much-heckled flax. When finely combed the fibre has the colour and lustre of fine-combed, bleached flax. [*Textilberichte*, 1922, **3**, 120–122. H. GUYOT.]

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INDIAN CINCHONA BARK AND MYROBALANS.

WE have received the following communication from the Imperial Institute for publication :—

A new volume in the series of Reports of the Indian Trade Enquiry conducted at the Imperial Institute has just been published by Mr. John Murray (price 4*s*.). It deals with cinchona bark, the source of quinine, and myrobalans, an important tanning material.

At the present time Java has a virtual monopoly in the production of cinchona bark, its closest competitor being India which produces only about 8 per cent. of the world's supply. Moreover the manufacture of quinine is largely under the control of Dutch interests, and of the 8,000,000 oz. used annually in the British Empire about 5,000,000 oz. have to be obtained from foreign sources. In view of the importance of the matter it is recommended that attempts should be made to produce in India sufficient bark to meet a much larger proportion of the Empire's requirements.

Cinchona has been introduced into several tropical parts of the Empire, and the volume contains the results of examination at the Imperial Institute of cinchona bark grown in St. Helena, Tanganyika, and the Cameroons.

Myrobalans, the dried fruits of a large tree, form one of the principal tanning materials used in India and are also largely exported. The amounts reaching this country have varied in recent years from about 500,000 cwt. to over 800,000 cwt., whilst prior to the war Germany and the United States were also large importers. Particulars are given in the Report as to the trade in myrobalans, their composition, and their use by British tanners and dyers, whilst suggestions are made with respect to the future trade in this product.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

Mr. G. Evans, C.I.E., M.A., Director of Agriculture, Bengal, has been granted combined leave for 28 months from or after the 11th October, 1922.

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Dr. N. Gupta has been appointed to officiate as Deputy Director of Agriculture, Presidency Division, Bengal, with head-quarters at Calcutta.

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Rai Rajesvar Das Gupta Bahadur, Deputy Director of Agriculture, Bengal, has been posted to the Burdwan Division with head-quarters at Chinsurah.

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Mr. H. C. Sampson, C.I.E., B.Sc., has been permitted to retire from the Indian Agricultural Service with effect from the 22nd December, 1923, the date of expiry of the leave granted to him.

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Mr. R. W. Littlewood, N.D.A., Deputy Director of Agriculture, Live Stock, Madras, has been granted combined leave for six months and 12 days from or after the 1st October, 1922, Mr. M. V. Raghavalu Nayudu officiating.

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The services of Mr. Roger Thomas, B.Sc., have been replaced at the disposal of the Government of Madras from the 24th May, 1922.

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Mr. Saadat-ul-lah Khan, B.A., Probationary Deputy Director of Agriculture, has been posted in charge of the VI Circle, Madras

Presidency, *vice* Mr. R. C. Broadfoot, N.D.A., granted combined leave for nine months from the 15th November, 1922.

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Mr. C. L. Berg, Assistant Executive Engineer (under training), P.W.D., Madras, has been appointed to act as Government Agricultural Engineer in the Agricultural Department, *vice* Mr. F. T. T. Newland granted leave or until further orders.

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Mr. K. Unnikrishna Menon, officiating in the Madras Agricultural Service, has been posted to the duties of the Superintendent, Central Farm, Coimbatore.

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Mr. P. C. Patil, L.Ag., Deputy Director of Agriculture, Bombay, who went on study leave to America to specialize in agricultural economics, has taken the degree of M.Sc. of the Wisconsin University.

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Mr. G. Taylor, M.R.C.V.S., Superintendent, C.V.D., Bombay, has been allowed an extension of furlough for six months.

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Mr. F. H. Vick, Agricultural Engineer to Government, United Provinces, has been granted combined leave for 15 months from or after 18th July, 1922, Mr. Wilayat Husain Cossar officiating.

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Mr. Bal Mukund Kapur has been appointed to officiate as Second Agricultural Engineer to Government, United Provinces, *vice* Mr. W. H. Cossar on other duty.

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Mr. A. C. Dobbs, B.A., has been confirmed in his appointment of Director of Agriculture, Bihar and Orissa, from the 6th January, 1920.

Mr. T. D. Stock, B.Sc., D.I.C., A.R.C.S., Economic Botanist, has assumed charge of the Myingyan Agricultural Circle, Burma, with head-quarters at Myingyan from the 1st September, 1922.

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The tenth annual meeting of the Indian Science Congress will be held at Lucknow from the 8th to 13th January, 1923.

The President of the Congress is Sir M. Visvesvaraya, K.C.I.E., M.Inst. C.E., D.Sc., and the Sectional Presidents will be as follows :—

Agriculture.	Dr. N. Kunjan Pillai, Director of Agriculture, Travancore.
Botany.	Mrs. G. L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa.
Chemistry.	Dr. A. N. Meldrum, Professor of Physics and Chemistry, Gujarat College, Ahmedabad.
Physics.	Dr. S. K. Banerji, Director, Bombay and Alibag Observatories, Bombay.
Geology.	Dr. E. H. Pascoe, Director of the Geological Survey of India, Calcutta.
Zoology.	Mr. G. Matthai, Professor of Zoology, Government College, Lahore.
Medical Research.	Lieut.-Colonel C. A. Sprawson, I.M.S., Principal and Professor of Medicine, King George's Medical College, Lucknow.
Anthropology.	Dr. J. J. Modi, Bombay.

In addition to the regular programme of the meetings of the scientific sections, a series of general scientific discussions has been organized, beginning with one on colloids by Dr. S. S. Bhatnagar of Benares. A series of illustrated public lectures on subjects of popular scientific interest has also been arranged.

Review

Co-operation in Germany, Italy and Ireland.—A report by M. L. DARLING, ESQ., I.C.S., formerly Joint Registrar, Co-operative Societies, Punjab. (Lahore : Government Press.) Price, Rs. 3-8-0.

THIS most able report is a welcome addition to works already produced by informed writers who know and understand the conditions under which the co-operative movement exists in India. The trouble from which many Indian co-operators suffer is their ignorance of precedent. Not that European precedent is always a safe guide where circumstances are very different. But it affords, at least, a starting point from which to work things out ; and Mr. Darling's account of the co-operative movement in Germany will come as a tonic to many who originally pinned their faith to self-help and then, because of the length and steepness of the road, inclined towards the support of State aid. "Germany", says Mr. Darling, "is a splendid example of self-help, as Italy is a warning of the danger of State aid. But Italy, too, is learning the lesson that sooner or later all must learn who ignore first principles."

Germany, however, has a deeper lesson to teach those who are interested in the co-operative movement in India. The founder of rural co-operation in Germany, Raiffeisen, was a sturdy and convinced opponent of State aid. Bismarck came on the scene and, at first, viewed the co-operative movement with suspicion. Here was a novel doctrine which was not military and might be pacifist. But it could be so influenced as to suit the policy of Imperial Germany.

Eagles and other decorations began to descend on leading co-operators ; and, whenever possible, orders for forage and other commodities for Army use were placed with co-operative institutions. Before the war the co-operative movement in Germany had learned something of the art of rattling the sabre, and patriotic songs of a distinctly aggressive type were sung at co-operative gatherings and banquets. And what of "after the war" ? Co-operators may well be grateful to Mr. Darling for telling them. The war brought shattering defeat ; and "defeat is kindling a spirit which could never have arisen out of victory and which expresses all that is best in the German race." The long uphill fight has begun again and it is this that invigorates. German co-operators are no longer able to turn to the State for financial favours. Politics are eschewed ; the public exchequer is empty. But still, the spirit of Raiffeisen and his doctrines live, and in the two years following the war 10,000 co-operative societies were opened. As Mr. Darling remarks, there could be no finer tribute to the power of Co-operation and the unconquerable spirit of man.

In Italy, the reader is told, co-operative societies fall into two main divisions. In the one are the societies controlled by the Socialist party which aims at the destruction of capitalism and the establishment of collectivism in its place. In the other are the societies controlled by the Catholics strongly entrenched in individualism. The hottest rivalry prevails and as the co-operative society is regarded in Italy as a source of political strength, both parties compete feverishly with each other to form societies. This factor, which has had much to do with the rapid speed of the movement in Italy, has only recently come into play, as it is only since the war that the Catholics have begun to take an open part in politics. Only less important than political rivalry is the lavish financial assistance given by Government. Millions of lire have been poured out, mainly in the hope that Co-operation would prove a sedative to the agrarian and industrial ferment produced by a long war on a not very phlegmatic people. Societies have sprung up like mushrooms, some with no more resources than a few 10 lire shares, believing that unlimited funds would be placed at their disposal by

Government. Even Italians are alarmed at the appearance of so many new societies, some of which have already had to be liquidated. The danger is accentuated by the almost total lack of organization for inspection and control, which has therefore had to be improvised in haste with insufficient funds and staff. It must be noted, in contrast, that in Germany an elaborate system of federations and unions ensures that as soon as a society is formed it shall come under skilled guidance and control. The absence of inspection and guidance and the sudden cessation of the flood of State money have resulted in the collapse of a large number of Italian societies. Italy may, however, yet be saved by men like Luzzatti just as the tradition of Raiffeisen has saved the co-operative movement in Germany. In two fields the achievements of Italy are brilliant and beyond anything achieved elsewhere. The Co-operative Farm and the Labour Society are now definitely established, and are even spreading across the Alps. They are her great contribution to Co-operation just as village banks with their unions and federations are Germany's.

In Ireland, with singular wisdom and restraint, politics have always been rigidly excluded, a fact that has been the salvation of Co-operation in that unhappy island. For years under the beneficent ægis of the Irish Agricultural Organization Society, men of all shades of opinion have been able to meet together in perfect amity. Opinion, both German and Irish, is to the effect that a society that takes to politics is as good as lost. Where Co-operation and Politics go hand in hand one must be dominant. If it is politics, Co-operation loses her freedom. Russia is the classic instance of this. If, on the other hand, it is Co-operation the temptation to turn political power to doubtful ends may prove irresistible. "The political danger," says Mr. Darling, "is indeed the only serious danger that Co-operation has to fear."

In order to understand Mr. Darling's book some acquaintance with the practical working of co-operative societies is necessary. The book is not for the elementary student. Certain portions, however, may be read with interest by the general reader, especially those which are descriptive of individual societies. The whole of

Mr. Darling's book should be read by every official connected with the co-operative movement and particularly by budding Registrars. Non-official workers, who find but little time for study, will welcome Mr. Darling's book not only for its breadth of outlook but for the fact that it consists of less than 200 pages of good clear print. [H. R. C.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

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1. Genetics. An Introduction to the Study of Heredity, by H. E. Walter. Revised Edition. Pp. xvi+354 ; 92 figs. (New York : Macmillan & Co.)
2. Elements of Plant Biology, by A. G. Tansley, F.R.S. (London : George Allen and Unwin.) Price, 10*s.* 6*d.*
3. The Psychic Life of Insects, by E. L. Bouvier. Translated by L. O. Howard. Pp. 377. (London : T. F. Unwin.) Price, 8*s.* 6*d.*
4. Live Stock and Farm Mechanics, by J. H. Gehrs. Pp. 393. (London : Macmillan & Co.) Price, 10*s.* 6*d.*
5. Cyclopedia of Farm Animals, edited by L. H. Bailey. Pp. xvi+708 ; 25 plates. (London : Macmillan & Co.) Price, 25*s.* net.
6. Cyclopedia of Farm Crops : A Popular Survey of Crops and Crop-making methods in the United States and Canada. Pp. xvi+699 ; 25 plates. (London : Macmillan & Co.) Price, 25*s.* net.
7. Agricultural Bacteriology, by J. Y. Greaves. Pp. 437. (Philadelphia : Lea and Febiger.) Price, 4 dollars.
8. Principles and Practice of Butter-making, by G. L. McKay and C. Larsen. Third Edition, largely rewritten. Pp. xiv+405. (New York : J. Wiley and Sons, Inc. ; London : Chapman & Hall, Ltd.) Price, 15*s.* net.
9. A Short History of British Agriculture, by John Orr. Pp. 96. (London : Oxford University Press.) Price, 2*s.* 6*d.* net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :

Memoirs.

1. A New Ginger Disease in Godavari District, by S. Sundararaman, M.A. (Botanical Series, Vol. XI, No. 9.) Price, R. 1 or 1*s.* 4*d.*
2. Studies in Rinderpest, by W. A. Pool, M.R.C.V.S., and T. M. Doyle, F.R.C.V.S. (Veterinary Series, Vol. III, No. 4.) Price, R. 1 or 1*s.* 4*d.*

Bulletins.

3. Report of Campaign against *Spodoptera mauritia*, Boisd. (*Noctuidæ*) in Malabar, by E. Ballard, B.A., F.E.S. (Bulletin No. 132.) Price, As. 2.
4. Some Observations on the Control of Field Rats in the Punjab, by M. A. Husain, M.A., and Hem Singh Pruthi, M.Sc. (Bulletin No. 135.) Price, A. 1.
5. Note on the Probability of an Inter-relation between the length of the Stigma and that of the Fibre in some forms of the genus *Gossypium*, by Ram Prasad. (Bulletin No. 137.) Price, As. 4.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st FEBRUARY TO 31st JULY, 1922.

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	*The Agricultural Journal of India*, Vol. XVII, Parts II, III & IV. Price R. 1-8 or 2*s*. per part; annual subscription Rs. 6 or 9*s*. 6*d*.	Edited by the Agricultural Adviser to the Government of India.	Messrs. Thacker, Spink & Co., Calcutta.
2	Proceedings of the Board of Agriculture in India held at Pusa on the 13th February, 1922, and the following days (with appendices). Price R. 1.	Agricultural Adviser to the Government of India.	Government Printing, India, Calcutta.
3	Cawnpore-American Cotton, II; Further Field Trials (1918-20), Spinning Trials and Market Organization. Pusa Agricultural Research Institute Bulletin No. 126. Price As. 4.	B. C. Burt, M.B.E., B.Sc., Secretary, Indian Central Cotton Committee.	Ditto
4	Agricultural Statistics of British India, 1919-20, Vol II. Price R. 1-8.	Issued by the Department of Statistics, India.	Ditto
5	Annual Report of the Board of Scientific Advice for India for 1920-21. Price As. 12.	Issued by the Board of Scientific Advice for India.	Ditto
6	A Note on Cotton (in English and Bengali).	D. Dutt, Offg. Second Economic Botanist to the Government of Bengal.	Bengal Secretariat Book Depôt, Calcutta.
7	Departmental Activities in Northern Bengal.	J. N. Sarkar, Offg. Deputy Director of Agriculture, Northern Circle, Bengal.	Ditto
8	A Note on Jute seed ..	Ditto	Ditto
9	*Bengal Agricultural Journal* (Quarterly) (In English and Bengali), March & June, 1922. Annual subscription R. 1-4; Single copy As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
10	Jute in Bengal (New Edition).	Nibaran Chandra Chowdhury, M.R.A.S.	Messrs. W. Newman & Co., Calcutta.
11	Season and Crop Report of Bihar and Orissa for 1921-22. Price R. 1.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.
12	Prospectus of the Punjab Agricultural College, Lyallpur (not for sale).	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
13	Report on the Failure of the Cotton Crop in 1919. Price Rs. 13-8.	D. Milne, B.Sc., Economic Botanist, Punjab.	Ditto
14	Report on the Cotton survey of the Multan district.	Harnam Singh, L. Ag., Agricultural Assistant, Lyallpur.	Ditto
15	Text-Book of Punjab Agriculture.	W. Roberts, B.Sc., and T. Faulkner, B.A.	Civil and Military Press, Lahore.
16	Triennial Report of the Experimental work of the Agricultural Station, Landhi, for the years 1918-19, 1919-20 and 1920-21. Price As. 4.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press, Poona.
17	Triennial Report of the Experimental work of the Agricultural Station, Mirpurkhas, for the years 1918-19, 1919-20 and 1920-21. Price As. 5.	Ditto	Ditto
18	Triennial Report of the Experimental work of the Agricultural Station, Larkhana, for the years 1918-19, 1919-20 and 1920-21. Price As. 3.	Ditto	Ditto
19	Triennial Report of the Experimental work of the Agricultural Station, Sukkur, for the years 1918-19, 1919-20 and 1920-21. Price As. 5.	Ditto	Ditto
20	Report of the Experimental work of the Ratnagiri Agricultural Stations for 4 years 1916-17 to 1919-20. Price As. 11.	Ditto	Ditto
21	Report of the Experimental work of the Kumta Agricultural Station for the 3 years 1917-1 to 1919-20. Price As. 5.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
22	Report of the Experimental work of the Ganeshkhind Botanical Garden, Kirkee, for the year 1919-20. Price As. 2.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press, Poona.
23	Summary of the work done on Jalgaon Farm. Bombay Department of Agriculture Bulletin No. 108 of 1921 (in Marathi). Price As. 2½.	Ditto	Ditto
24	Tobacco—A profitable new crop for Kanara District. Bombay Department of Agriculture Leaflet No. 5 of 1921.	Ditto	Ditto
25	Green manuring of "Nagli" with "San." Bombay Department of Agriculture Leaflet No. 2 of 1922.	Ditto	Ditto
26	Annual Reports of Agricultural Stations of the Madras Presidency for 1921-22. (For official use only.)	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
27	A Soil Survey of the Godavari Delta. Madras Department of Agriculture Bulletin No. 83.	Roland V. Norris, D.SC., Government Agricultural Chemist, Madras, B. Viswanath and K. Kasinath Ayyar.	Ditto
28	Villagers' Calendar for 1922-23 .	Issued by the Department of Agriculture, Madras.	Ditto
29	Prickly Pear as fodder. Madras Department of Agriculture Leaflet No. 17.	Ditto	Ditto
30	Report on the Agricultural College, Nagpur, Botanical, Chemical and Mycological Research, Maharaj Bagh Menagerie and Agricultural Engineer's Section for 1920-21. Price As. 8.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Nagpur.
31	Report on the Experimental Farm attached to the Agricultural College, Nagpur, for 920-21. Price As. 8.	Ditto	Ditto
32	Report on the Agricultural Stations, Western Circle, Central Provinces, for 1918-19. Price As. 8.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
33	Report on Demonstration Work in the Western Circle, Central Provinces, for 1918-19. Price As. 8.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Nagpur.
34	Report on the Agricultural Stations in the Western Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
35	Report on the Demonstration Work in the Western Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
36	Report on the Agricultural Stations in the Northern Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
37	Report on the Demonstration Work in the Northern Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
38	Report on the Agricultural Stations in the Southern Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
39	Report on the Demonstration Work in the Southern Circle, Central Provinces, for 1920-21. Price As. 8.	Ditto	Ditto
40	Engineering Section of the Central Provinces Department of Agriculture Leaflet. (Hindi and Marathi.)	Ditto	Ditto
41	Hire-purchase system of motor tractors. Central Provinces Department of Agriculture Leaflet. (Hindi and Marathi.)	Ditto	Ditto
42	How cane growers can increase their profits. Central Provinces Department of Agriculture Leaflet. (Hindi.)	Ditto	Ditto
43	By-laws for Seed and Taluq Associations. Central Provinces Department of Agriculture Leaflet. (Marathi.)	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
44	Wheat suitable for different districts of Northern Circle. Central Provinces Department of Agriculture Leaflet. (Hindi.)	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Nagpur.
45	Season and Crop Report of Assam for 1921-22. Price As. 8.	Issued by the Department of Land Records and Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
46	Report of the Jorhat Agricultural Experiment Station for the year ending 31st March, 1922.	Ditto	Ditto
47	Report of the Upper Shillong Agricultural Experiment Station for the year ending 31st March, 1922.	Ditto	Ditto
48	Report of the Karimganj Agricultural Experiment Station for the year ending 31st March, 1922.	Ditto	Ditto
49	Tables of Agricultural Statistics of Lower Burma for 1920-21.	Issued by the Department of Settlements and Land Records, Burma.	Government Printing, Burma, Rangoon.
50	Annual Reports of the Agricultural Stations, the Agricultural Chemist, the Agricultural Engineer, the Economic Botanist and the Assistant Director of Agriculture (Entomology) for the year ended 30th June, 1921.	Issued by the Department of Agriculture, Burma.	Ditto
51	Agricultural Calendar for 1922-23 (only in Burmese).	Ditto	Ditto
52	Revision and reprinting of the syllabus for the Agricultural College, Mandalay.	Ditto	Ditto
53	Instructions and handling of cane crushers (in Burmese).	Ditto	Ditto
54	*The Journal of the Madras Agricultural Students' Union.* Annual subscription Rs. 2.	Madras Agricultural Students' Union.	Literary Sun Press, Coimbatore.
55	*Indian Scientific Agriculturist* (Monthly). Annual subscription Rs. 4.	Alliance Advertising Association, Ltd., Calcutta.	Bera and Co., Printers, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
56	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
57	*Poona Agricultural College Magazine* (Quarterly). Annual subscription Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
58	*Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual subscription Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
	BOTANY		
59	A Handbook of Some South Indian Grasses. Price Rs. 4-8.	Rao Bahadur K. Rangachari, M.A., L.T., Government Lecturing Botanist, Agricultural College, Coimbatore.	Messrs. Butterworth & Co., Calcutta.
60	A Manual of Elementary Botany for India. Price Rs. 4.	Rao Bahadur K. Rangachari, M.A., L.T., Government Lecturing Botanist, Agricultural College, Coimbatore.	Government Press, Madras.
61	Correlation of colour characters in Rice. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XI, No. 7. Price R. 1-4 or 1*s.* 8*d.*	G. P. Hector, M.A., B.SC., Economic Botanist to the Government of Bengal.	Messrs. Thacker, Spink and Co., Calcutta.
	MYCOLOGY		
62	Coconut Bleeding Disease. Pusa Agricultural Research Institute Bulletin No. 127. Price As. 8.	S. Sundararaman, M.A., Government Mycologist, Madras.	Government Printing, India, Calcutta.
63	*Helminthosporium* Disease of Rice. Pusa Agricultural Research Institute Bulletin No. 128. Price As. 9.	Ditto	Ditto
64	Some Common Fungoid Diseases of Crops and their preventive measures.	P. C. Kar, Mycological Assistant, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
65	Note on Mildew on Grapes and How to Prevent it. Madras Department of Agriculture Leaflet No. 16.	S. Sundararaman, M.A., Government Mycologist, Madras.	Government Press, Madras.
66	Notes on the Smut Diseases of Juar and Their Prevention. Central Provinces Department of Agriculture Leaflet.	R. T. Pearl, B.SC., Mycologist, Central Provinces.	Government Press, Nagpur.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Mycology—concld.		
67	A Simple Method of Prevention of Smut in Juar. Central Provinces Department of Agriculture Leaflet.	R. T. Pearl, B.Sc., Mycologist, Central Provinces.	Government Press, Nagpur.
	ENTOMOLOGY		
68	New and Rare Indian Odonata in the Pusa Collection; Further Notes on Rhinocypha Larvæ. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. VII, Nos. 7 & 8. Price R. 1-4 or 1*s.* 9*d.*	Major F. C. Fraser, I.M.S.	Messrs. Thacker, Spink & Co., Calcutta.
69	The Weevil Fauna of South India with special reference to species of Economic importance. Pusa Agricultural Research Institute Bulletin No. 125. Price R. 1-4.	T. V Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., Assistant Entomologist, Madras.	Government Printing, India, Calcutta.
70	Insect Pests and General Measures for Prevention and Remedy (in Napali.)	P. C. Sen, Entomological Assistant, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
	VETERINARY		
71	Preparation of Anti-rinderpest Serum using Animals of moderate susceptibility as Virus Producers. Part I—Buffaloes. Pusa Agricultural Research Institute Bulletin No. 129. Price As. 12.	W. A. Pool, M.R.C.V.S., Offg. Director and First Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, and T. M. Doyle, F.R. C.V.S., Veterinary Officer, Muktesar.	Government Printing, India, Calcutta.
72	Feeding experiments at Government Cattle Farm, Hissar. Pusa Agricultural Research Institute Bulletin No. 130. As. 3.	R. Branford, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar, and E. Sewell, M.C., M.R.C.V.S., Professor, Punjab Veterinary College, Lahore.	Ditto
73	Feeding and Management of Young Stock Central Provinces Department of Agriculture Bulletin No. 14 of 1922.	J. V. Takle, L.Ag., N.D.D. (I.). Agricultural College Dairy, Nagpur.	Government Press, Nagpur.
74	Value of a good Bull. Central Provinces Department of Agriculture Bulletin No. 15 of 1922.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title	Author	Where published
		Veterinary—concld.	
75	Improvement of Cattle for Draught and Dairying. Central Provinces Department of Agriculture Leaflet.	S. T. D. Wallace, B.SC., Nagpur.	Government Press, Nagpur.
76	Better Cattle. Central Provinces Department of Agriculture Leaflet.	Ditto	Ditto
77	Notes on Glanders and Epizootic Lymphangitis. Burma Veterinary Department Note.	Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
78	Cattle Breeding and Rearing. (In English and Burmese.) Burma Veterinary Department Leaflet.	Ditto	Ditto